

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
CALCULATION COVER SHEET

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ACRONYMS AND ABBREVIATIONS

ANSYS	Analysis System (computer code)
Btu	British Thermal Unit
BWR	Boiling Water Reactor
°C	Degree Centigrade
CSNF	Commercial Spent Nuclear Fuel
CRWMS	Civilian Radioactive Waste Management System
CSCI	Computer Software Configuration Item
DOE	U.S. Department of Energy
DC	Document Control
DS	Drift Spacing
°F	Degree Fahrenheit
ft	Foot
ft ²	Square Foot
FV	Forced Ventilation
hr	Hour
J/kg·K	Joules per Kilogram Kelvin
K	Degree Kelvin
kg	Kilogram
kW	Kilowatt
LL	Initial Linear Heat Load
m	Meter
M&O	Management and Operating Contractor
m ²	Square Meter
m ³	Cubic Meter
NV	Natural Ventilation
PWR	Pressurized Water Reactor
s	Second
SDD	System Description Document
SGI	Silicon Graphics Incorporated
SR	Site Recommendation

ACRONYMS AND ABBREVIATIONS (Continued)

TDMS Technical Data Management System
TIC Technical Information Center

WP Waste Package
W/m·K Watt per Meter Kelvin

Yr Year

2D Two-dimensional

1. PURPOSE

The objective of this calculation is to calculate the effects of forced ventilation during the repository preclosure period and natural ventilation within the potential repository after the forced ventilation ceases on temperatures, to examine the temperature difference obtainable across the drift length during the ventilation, to predict the maximum temperatures of emplacement drift wall and waste package surface following closure of the drift system after the period of natural ventilation, and to estimate the heat removal efficiencies by ventilation. The calculation provides input to the natural ventilation parametric study (CRWMS M&O 2000a, Sections 1 and 2).

The scope of the calculation is to identify the physical mechanisms and parameters related to thermal response in the emplacement drifts, and apply numerical methods that can be used to calculate the effect of both forced and natural ventilation. Sensitivity studies to assess the impact of variation of linear power densities (linear heat loads), ventilation air flow rates including both forced and natural ventilation, and rock mass thermal conductivity values are included. The calculation is limited to thermal effect only.

Additional work of determining (1) the flow rate of natural ventilation using the fluid dynamics of the flow circuit across the repository, (2) the minimum linear power density to drive natural ventilation, and (3) the point at which the natural ventilation ceases to provide adequate removal of thermal energy to meet thermal design goals is also indicated in the *Technical Work Plan for: Natural Ventilation Parametric Study* (CRWMS M&O 2000a, Section 1), but is not covered in this calculation.

This work activity has been evaluated in accordance with the AP-2.21Q procedure, *Quality Determinations and Planning for Scientific, Engineering, and Regulatory Compliance Activities*, and is subject to QA controls (CRWMS M&O 2000a, Section 17). The calculation is developed in accordance with the AP-3.12Q procedure, *Calculations*, and prepared in accordance with the *Technical Work Plan for: Natural Ventilation Parametric Study* (CRWMS M&O 2000a).

2. METHOD

This calculation uses the numerical code ANSYS Version 5.2 (CRWMS M&O 2000e) to predict the effects of both forced and natural ventilation on temperatures of the emplacement drift wall and the waste package surface during the repository preclosure and postclosure periods. The code applies the following scientific laws in predicting temperature distributions: Fourier's Law, Newton's Law of cooling, and the Stefan-Boltzmann Law (CRWMS M&O 1997) (Swanson Analysis Systems 1995, Volume IV, Sections 6.1.1 and 6.1.2). Only two-dimensional (2D) cases were analyzed.

Primary data were selected from the Technical Data Management System (TDMS), Technical Information Center (TIC), Document Control (DC), and input transmittal in accordance with the AP-3.14Q procedure, *Transmittal of Input*. The use or control of electronic media for data is not required (CRWMS M&O 2000a, Section 10). There is no variance in the method used from that planned (CRWMS M&O 2000a, Section 4). Details of the approach used in the calculation are provided in Section 5.

3. ASSUMPTIONS

The following assumptions are used in this calculation. Some of the assumptions are based on preliminary and unqualified data, and justification for use in this calculation is provided in accordance with AP-3.12Q procedure, *Calculations*.

- 3.1 (a) Waste packages are emplaced simultaneously in all the emplacement drifts. (b) The emplacement area covers the entire horizontal plane, meaning that the edge effect on the temperature distribution is neglected. These assumptions allow the use of 2D models for the calculation, and are expected to result in over-predictions of temperature increase, especially for the repository edge. Therefore, further confirmation is not required. Used in Sections 5 and 6.
- 3.2 The average rock temperature on surface is assumed to be 18.7°C. The in-situ rock thermal gradient is assumed as 0.020°C/m for depth 0 to 150 meters, 0.018°C/m for depth 150 to 400 meters, 0.030°C/m for depth 400 to 536 meters. The in-situ thermal gradient for depth 536 to 700 meters is assumed to be the same (0.030°C/m) as for depth 400 to 536 meters. This assumption is based on the temperature profile in borehole USW G-4 (Sass et al. 1988, p. 48 and Figure 1-12), which is located in the area of Panel 1. In addition, the ventilation inlet air temperature is assumed to be the same as the initial rock temperature at the emplacement drift horizon. These data are considered adequate and appropriate for use in this calculation. Used in Section 5.3.2.
- 3.3 (a) The emplacement drifts will be ventilated during the preclosure period to support thermal goals (CRWMS M&O 2000c, Sections 1.2.1.8 and 1.2.1.9). (b) The following values for duration of the preclosure forced ventilation after waste emplacement are assumed: 26, 50 and 75 years. (c) The values for duration of the postclosure natural ventilation are assumed to be 300, 500, and 10,000 years. These values are assumed as part of a sensitivity study, and, thus, further confirmation is not required. Used in Sections 5 and 6, and Attachments I through XXVII.
- 3.4 In calculation of convection heat transfer coefficient for both forced and natural ventilation, forced convection is dominant while the effect of free convection is negligible. With forced ventilation, the associated Reynolds number is usually well beyond 4,000 (CRWMS M&O 1999a, Table 5-11), indicating that the flow is turbulent and forced convection is dominant. With natural ventilation, though the flow rate is relatively low, the associated Reynolds number will likely exceed 4,000, indicating that the flow is also turbulent. Therefore, forced convection is still dominant. Used in Section 5.3.3.3.
- 3.5 The effective length of emplacement drifts for ventilation air flow is assumed to be 600 m. This assumption is based on the *Subsurface Facility System Description Document* (CRWMS M&O 2000d, Section 2.2.2.4). Used in Sections 5 and 6, and Attachments II through XXVII.

- 3.6** The initial temperature on waste package surface is assumed to be 70°C. This assumption is based on the average initial temperature on waste package surface calculated in the *Multiple WP Emplacement Thermal Response – Suite 1* (CRWMS M&O 1998c, Tables 6-1 through 6-4). Used in Section 6 and Attachments II through XXVI.
- 3.7** The starting average relative humidity of emplacement drift inlet air is assumed to be 30 percent based on the *Post Closure Open Loop Natural Ventilation* (CRWMS M&O 1999c, Section 3.4, p. 6). Used in Attachment XXVII.
- 3.8** The average barometric pressure at the emplacement drift level is assumed to be 26.2 inches mercury according to the *Post Closure Open Loop Natural Ventilation* (CRWMS M&O 1999c, Section 3.4, p. 6). Used in Attachment XXVII.
- 3.9** The average conservative worst case water influx rate into the emplacement drifts is assumed to be 60 mm per year for 10,000 years. This assumption is based on the *Post Closure Open Loop Natural Ventilation* (CRWMS M&O 1999c, Section 3.12, p. 9). Used in Attachment XXVII.
- 3.10** Rock thermal properties are used as listed in Table 5-1. These data are taken from DTN: SN0003T0571897.013, which has been superseded by DTN: SN0011T0571897.014. Though the newer data for thermal conductivity and specific heat are not identical to the older values listed in Table 5-1, differences are not substantial, and impact of these differences on the results is considered insignificant. In addition, all thermal analyses conducted were based on the older data, and this interim change (ICN) is not intended to address the impact of this data change on the results. Therefore, the use of the data as provided in DTN: SN0003T0571897.013 is adequate and appropriate. Used in Section 5.1.4.
- 3.11** Waste package parameters and related values are used as listed in Table 5-4 of Section 5.1.5.1 for the commercial spent nuclear fuel (CSNF) inventory, Table 5-5 of Section 5.1.5.2 for the volumetric heat generation rates of CSNF waste packages, and Section 5.1.5.4 for the 21-PWR waste package length and diameter. These values are obtained from the *Enhanced Design Alternative (EDA) II Repository Estimated Waste Package Types and Quantities* (CRWMS M&O 2000b, Item 1, Table 8, and Item 2, Tables 1, 3 and 4). They are design outputs, and will vary with design. Used in Sections 5.1.5.1, 5.1.5.2, and 5.1.5.4 and Attachment I.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 ANSYS COMPUTER SOFTWARE

A commercially available computer program, ANSYS Version 5.2 (CSCI#: 30013 V5.2SGI), was used to support the calculation. This is a baselined version (not version 5.4) of the software currently installed in the Subsurface Facilities Department. ANSYS is a general purpose, finite element analysis code, and is used in many disciplines of engineering, including structural, geotechnical, and mechanical, concerning thermal behavior of solids and fluids. The ANSYS Version 5.2 is installed on Silicon Graphics (SGI) and Sun Microsystems workstations with the Unix operating system. The ANSYS Version 5.2 has been verified and validated (CRWMS M&O 1997) according to the AP-SI.1Q procedure, *Software Management*. ANSYS Version 5.2 was used in thermal calculations for predicting the effect of waste emplacement. The input and output files for the ANSYS runs were archived and submitted to the Technical Data Management System (TDMS) and the Records Processing Center (DTNs: MO0010MWDANS03.005 and MO0103MWDTEM00.007). A detailed discussion of the general features and fields of the application of the ANSYS code is presented in the User's Manual (Swanson Analysis Systems 1995).

The ANSYS Version 5.2 software was obtained from the Software Configuration Management in accordance with the AP-SI.1Q procedure. The software was appropriate for the applications used in this calculation. The software was used within the range of validation as specified in the software qualification report (CRWMS M&O 1997).

Use of the ANSYS software to perform scientific and engineering calculations and analyses has been widely accepted in the nuclear industry and other related engineering fields. The software was developed based on the following established mathematical and engineering theories and laws: Fourier's Law, Newton's Law of Cooling, and Stefan–Boltzmann Law. Selection of this software for the calculation indicates the adoption of these underlying scientific and engineering laws. Validation of these laws or mathematical models involves the examination of mathematical theories and the results of laboratory and field tests. The model validation also includes identification of scientific and engineering literature, parameter inputs, assumptions, initial and boundary conditions, and limitations. Since the ANSYS software has been validated and verified by the Project, in addition to the rigorous validation conducted by the software vendor before the release of the software, the underlying mathematical models are determined to be validated for use as long as the use is within the range of validation.

4.2 SPREADSHEET SOFTWARE

Microsoft Excel 97 spreadsheet software was used in calculating the heat generation rates used as inputs to the ANSYS models and in demonstrating some of the ANSYS results graphically. In the former application, simple arithmetic operations, such as addition, subtraction, multiplication, and division, were used. These calculations are presented in Attachments I through XXVII. In the latter application, the results from the ANSYS models were used as inputs, and the outputs are presented in the forms of figures in Attachments II through XXVII. User-defined formulas and/or algorithms are displayed where used. Both the inputs and outputs

used in Excel are provided in DTNs: MO0010MWDANS03.005 and MO0103MWDTEM00.007.

Microsoft Excel 97 is an exempt software product in accordance with AP-SI.1Q procedure, *Software Management*.

5. CALCULATION

This section presents the inputs, theoretical background, and approaches used in the calculation. Some of the input data presented in this section are considered preliminary, and/or may not reflect the latest information, such as the representative location of emplacement drifts and the thicknesses of stratigraphic units, the waste inventory data, and the waste package dimensions. Since several previous calculations have used these data to support the subsurface layout design for Site Recommendation, for comparison purposes, the same input values were chosen for this feasibility study. Variation of these data would have an impact on the results.

5.1 INPUTS

5.1.1 Stefan–Boltzmann Constant

For thermal radiation calculations, the Stefan–Boltzmann constant value of $5.669 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4$ is used (Holman 1997, p. 396).

5.1.2 Forced and Natural Ventilation Air Flow Rates

An air flow rate of $15 \text{ m}^3/\text{s}$ is used for the forced ventilation during the preclosure period (CRWMS M&O 2000c, Section 2.3.2, p. 28). This flow rate is kept constant in modeling for the preclosure periods of 26, 50, and 75 years (Section 3.3).

For the natural ventilation, the air flow rates used are $1, 1.5, 2, 2.5, 3, 4$, and $5 \text{ m}^3/\text{s}$, and selected as part of a sensitivity study. Since the air flow rate of natural ventilation varies with temperature, air pressure, and time, its determination is a very complex subject and beyond the scope of this calculation. For the purpose of this parametric study, the air flow rates for the natural ventilation are either varied (piecewisely constant) or kept constant for the ventilation duration of 300, 500, and 10,000 years less the preclosure period considered (Section 3.3).

5.1.3 Depth of Rock Units

The thicknesses of the lithostratigraphic rock units are listed in Table 5-1. These are the values at the point (N233,760 m, E170,750 m) of the proposed repository area based on the *Thermal Modeling Parameters by Stratigraphic Unit* (CRWMS M&O 1999b; DTN: SN0003T0571897.013). The average elevations of the surface and the repository levels at this location are 1,421.28 m (4,663 ft) (CRWMS M&O 1999b) and 1,072.30 m (CRWMS M&O 1998a, Figure 4-1, p. 19), respectively. Therefore, the depth of the repository level (the invert) is 348.98 m ($1,421.28 - 1,072.30 = 348.98 \text{ m}$) from the surface.

The depth of each rock unit listed in Table 5-2 is calculated based on the elevations of the surface (1,421.28 m) and the Tpcpv2 unit (1,306.98 m) (4,288 ft), and the thickness of each rock unit (CRWMS M&O 1999b). The information is then used to determine the y-coordinates (vertical) (see Table 5-2) of the top and/or bottom of each unit lying above and below the emplacement drifts, respectively, for the ANSYS models. The origin of the coordinates is set at the center of the emplacement drifts.

Table 5-1. Thermal Modeling Parameters for Rock by Stratigraphic Unit

T/M Unit	Stratigraphic Unit	ISM 3.0	Thickness	Grain Density	Thermal Conductivity		Specific Heat				
					T≤100°C	T>100°C	T≤95°C	95°C<T≤114°C	T>114°C		
			(m)	(kg/m³)	(W/m·K)	(J/kg·K)					
TCw	Tpcrv		Not Present								
	Tpcrn										
	Tpclr										
	Tpcpul										
	Tpcpmn										
	Tpcpll										
	Tpcpln										
	Tpcplnc										
PTn	Tpcpv	3	Tcpv3	0.0	2470	0.98	0.54	857	4570		
		2	Tcpv2	5.49							
	Tpcpv1		Tcpv1	4.69	2380	1.07	0.50	1037	6048		
	Tpbt4		Tcbt4	0.53	2340	0.5	0.35	1077	21976		
	Tpy		Yucca	7.05	2400	0.97	0.44	849	16172		
	Tpbt3		Tcbt3_dc	4.58	2370	1.02	0.46	1016	20669		
	Tpp		Pah	14.09	2260	0.82	0.35	1330	25560		
	Tpbt2		Tpbt2	9.69	2370	0.67	0.23	1224	23878		
	Tptrv3		Tptrv3	4.58	2510	1.00	0.37	834	5137		
	Tptrv2		Tptrv2	0.53							
TSw1	Tptrv1		Tptrv1	1.06							
	Tptrn		Tptrn	46.85	2550	1.62	1.06	866	5629		
	Tptrl		Tptrl	8.98	2510	1.58	0.89	882	5693		
	Tptpul		Tptpul	77.68	2510	1.80	0.71	883	5694		
TSw2	Tptpmn		Tptpmn	29.94	2530	2.33	1.56	948	4568		
	Tptpll		Tptpll	106.21	2540	2.02	1.20	900	4663		
	Tptpln		Tptpln	47.73	2560	1.84	1.42	865	4523		
TSw3	Tptpv3		Tptpv3	20.61	2360	2.08	1.69	984	1958		
CHn1	Tptpv2		Tptpv2	2.99							
	Tptpv1		Tptpv1	11.27							
	Tpbt1		Tpbt1	3.35							
	Tac5	Tac(v)	Calico	84.37	2310	1.31	0.7	1057	21076		
	Tac4				2240	1.17	0.58	1201	23863		
	Tac3				2350	1.2	0.61	1154	1201		
	Tac2	Tac(z)			2440	1.35	0.73	1174	22086		
	Tac1								1154		
CHn2	Tacb								1174		

Source: CRWMS M&O 1999b. The data except the density can also be found in DTN: SN0003T0571897.013.

Table 5-2. Depth and Coordinates of Stratigraphic Unit

USGS Unit	Depth (m)	Y-Coordinate (m)
Tpcpv3_top	0	346.23
Tpcpv2_top	114.30	231.93
Tpcpv1_top	119.79	226.44
Tpbt4_top	124.48	221.75
Tpy_top	125.01	221.22
Tpbt3_top	132.06	214.17
Tpp_top	136.64	209.59
Tpbt2_top	150.73	195.50
Tptrv3_top	160.42	185.81
Tptrv2_top	165.00	181.23
Tptrv1_top	165.53	180.70
Tptrn_top	166.59	179.64
Tptrl_top	213.44	132.79
Tptpul_top	222.42	123.81
Tptpmn_top	300.10	46.13
Tptpll_top	330.04	16.19
Tptpll_bottom	436.25	-90.02
Tptpln_bottom	483.98	-137.75
Tptpv3_bottom	504.59	-158.36
Tptpv2_bottom	507.58	-161.35
Tptpv1_bottom	518.85	-172.62
Tpbt1_bottom	522.20	-175.97
[Tac(v), Tac(z), Tacbt] bottom	606.57	-260.34

Sources: CRWMS M&O 1998a and DTN: SN0003T0571897.013.

5.1.4 Rock Properties

The rock grain density, thermal conductivity, and specific heat values are used in the thermal modeling. The values of these properties for each rock unit are listed in Table 5-1, based on the *Thermal Modeling Parameters by Stratigraphic Unit* (CRWMS M&O 1999b; DTN: SN0003T0571897.013). The emissivity of the rock unit Tptpll is set to be 0.9, which is equal to an average emissivity value for concrete surface (Incropera and DeWitt 1985, p. 780).

As part of sensitivity studies, the thermal conductivity values of every rock unit are amplified or reduced by 25 percent by multiplying the original thermal conductivity values provided in Table 5-1 by 1.25 or 0.75, to examine the sensitivity of temperatures to the variation in rock thermal conductivity. The amplified and reduced thermal conductivity values used in this calculation are presented in Table 5-3.

For use of these data, see Section 3.10.

Table 5-3. Amplified and Reduced Thermal Conductivity Values for Stratigraphic Units

Stratigraphic Unit	Amplified Thermal Conductivity (W/m·K)		Reduced Thermal Conductivity (W/m·K)	
	T≤100°C	T>100°C	T≤100°C	T>100°C
Tpcpv	1.23	0.68	0.74	0.41
Tpcpv1	1.34	0.63	0.80	0.38
Tpbt4	0.63	0.44	0.38	0.26
Tpy	1.21	0.55	0.73	0.33
Tpbt3	1.28	0.58	0.77	0.35
Tpp	1.03	0.44	0.62	0.26
Tpbt2	0.84	0.29	0.50	0.17
Tptrv3	1.25	0.46	0.75	0.28
Tptrv2				
Tptrv1				
Tptrn	2.03	1.33	1.22	0.80
Tptrl	1.98	1.11	1.19	0.67
Tptpul	2.25	0.89	1.35	0.53
Tptpmn	2.91	1.95	1.75	1.17
Tptpll	2.53	1.50	1.52	0.90
Tptpln	2.30	1.78	1.38	1.07
Tptpv3	2.60	2.11	1.56	1.27
Tptpv2				
Tptpv1				
Tpbt1	1.64	0.88	0.98	0.53
Tac(v)	1.46	0.73	0.88	0.44
Tac(z)	1.50	0.76	0.90	0.46
Tacbt	1.69	0.91	1.01	0.55

5.1.5 Waste Package Parameters and Properties

5.1.5.1 CSNF Waste Package Inventory

The estimated numbers of various types of commercial spent nuclear fuel (CSNF) waste packages are shown in Table 5-4 (CRWMS M&O 2000b, Item 2, Table 1). These numbers are used with the time-dependent heat generation rates for the various packages to estimate the overall heat decay percentage with respect to the total initial heat output of the waste packages as described below.

For use of these data, see Section 3.11.

Table 5-4. CSNF Waste Package Inventory

Waste Package Type	Number of Waste Packages
21-PWR, Absorber Plates	4,279
21-PWR, Control Rods	87
12-PWR, Long	158
44-BWR, Absorber Plates	2,889
24-BWR, Thick Absorber Plates	6

Source: CRWMS M&O 2000b, Item 2, Table 1

5.1.5.2 Volumetric Heat Generation Rates for CSNF Waste Packages

The volumetric heat generation rates for each of the waste package types listed in Table 5-4 are used in the 2D models.

The average time-dependent heat generation rates (kilowatts per waste package) for the CSNF waste packages of each type are given as a function of time in Table 5-5 (CRWMS M&O 2000b, Item 2, Table 3). These values are used with the numbers of each type of package (Table 5-4) as a basis for determining the time-dependent decay percentage with respect to the initial heat output of the waste packages. Details of the calculation of the time-dependent heat decay percentages are provided in Attachment I. These percentages are then used to determine the volumetric heat generation rates used in the 2D models. (See Attachment I)

For use of these data, see Section 3.11.

5.1.5.3 Physical and Thermal Properties of Waste Package

The physical and thermal properties for the representative waste package used in the calculation are listed in Table 5-6. These values are for Alloy 22 material. Among them, the thermal conductivity and specific heat values are obtained from the *Physical and Chemical Characteristics of Alloy 22* (DTN: MO0003RIB00071.000), the emissivity value is based on the *CRC Handbook of Chemistry and Physics* (Lide 1995, p. 10-297), and the density value is taken from the *Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip* (ASTM B 575-97 1998, p. 2).

5.1.5.4 Length and Diameter of 21-PWR Waste Package

The length and diameter used for all 21-PWR waste packages are 5.305 m and 1.564 m, respectively, based on the *Enhanced Design Alternative (EDA) II Repository Estimated Waste Package Types and Quantities* (CRWMS M&O 2000b, Item 1, Table 8).

For use of these data, see Section 3.11.

Table 5-5. Average Heat Generation Rates for CSNF Waste Packages

Time (year)	21-PWR Absorber Plates (kW/package)	21-PWR Control Rods (kW/package)	12-PWR Long (kW/package)	44-BWR Absorber Plates (kW/package)	24-BWR Absorber Plates (kW/package)
0.01	11.3337	2.3709	9.5402	7.1346	0.491
1	10.9954	2.3285	9.2722	6.9146	0.4829
5	9.9653	2.1785	8.4286	6.2682	0.4445
10	8.9956	2.0095	7.5901	5.6536	0.403
15	8.1887	1.8547	6.8815	5.1467	0.3689
20	7.5138	1.7241	6.3149	4.7102	0.3341
26	6.8050 ^a	1.5819 ^a	5.7089 ^a	4.2419 ^a	0.3013 ^a
30	6.3792	1.4942	5.3407	3.9701	0.2806
40	5.4984	1.3106	4.5868	3.3915	0.2369
50	4.7912	1.1649	3.9792	2.9326	0.2033
55	4.4921	1.1015	3.7277	2.7368	0.1889
60	4.2229	1.0443	3.5026	2.5621	0.1754
70	3.7685	0.9479	3.1031	2.2625	0.1536
75	3.5654	0.907	2.9482	2.1366	0.1445
80	3.3915	0.8698	2.7908	2.0227	0.1361
90	3.0866	0.807	2.5304	1.8264	0.1222
100	2.8314	0.7545	2.3024	1.6685	0.1111
125	2.4552 ^a	0.6764 ^a	1.9895 ^a	1.4331 ^a	0.0955 ^a
150	2.079	0.5983	1.6766	1.1977	0.0799
200	1.7291	0.5244	1.3818	0.9878	0.0684
250	1.5128	0.4796	1.2029	0.8725	0.0622
300	1.3654	0.4452	1.0804	0.7889	0.0583
400	1.1571	0.395	0.9118	0.6679	0.0528
500	1.0046	0.3492	0.7901	0.5821	0.0485
600	0.8839	0.3167	0.6928	0.5188	0.0449
700	0.7888	0.2873	0.618	0.4629	0.0415
800	0.7071	0.2629	0.5533	0.4202	0.0386
900	0.6367	0.2415	0.4962	0.3832	0.0367
1000	0.5804	0.2245	0.4538	0.3538	0.0346
1500	0.3969	0.1653	0.3077	0.2477	0.0283
2000	0.3093	0.1363	0.2395	0.1984	0.0247
3000	0.2402	0.1134	0.182	0.1593	0.0221
4000	0.2167	0.1042	0.1664	0.1421	0.0206
5000	0.1995	0.0977	0.1529	0.1307	0.0194
6000	0.1867	0.0916	0.1428	0.1214	0.0185
7000	0.1728	0.0869	0.1315	0.1131	0.018
8000	0.1619	0.0823	0.1236	0.106	0.017
9000	0.1523	0.0781	0.1162	0.099	0.0158
10000	0.1432	0.0739	0.1088	0.0924	0.0154

Note: ^a Values linearly interpolated for this calculation.

Source: CRWMS M&O 2000b, Item 2, Table 3 |

Table 5-6. Physical and Thermal Properties for Waste Package

Parameter	Value
Density (kg/m ³)	8690 ^d
Thermal Conductivity (W/m·K)	12.53 ^a
Specific Heat (J/kg·K)	435.25 ^b
Emissivity	0.87 ^c

Note:^a Averaged value over the temperature range of 48 to 300°C (DTN: MO0003RIB00071.000).

^b Averaged value over the temperature range of 52 to 300°C (DTN: MO0003RIB00071.000).

^c Value for alloy (80 Ni-20 Cr) at 100°C (Lide 1995, p. 10-297).

^d ASTM B 575-97 1998, p. 2.

5.1.6 Ventilation Air Properties

Ventilation air properties are listed in Table 5-7. These values except that for the air density are obtained based on an intake air temperature of 25°C (298 K) and using linear interpolation from Holman (1997, p. 646). The air density used is obtained from the *Repository Subsurface Waste Emplacement and Thermal Management Strategy* (CRWMS M&O 1998b, p. II-2).

Table 5-7. Properties for Ventilation Air at 25°C (298 K)

Parameter	Value
Density (kg/m ³)	1.0561 ^a
Thermal Conductivity (W/m·K)	0.0261 ^b
Specific Heat (J/kg·K)	1,005.7 ^b
Dynamic Viscosity (kg/m·s)	1.8363×10 ⁻⁵ ^b
Prandtl Number (dimensionless)	0.709 ^b

Sources: ^a CRWMS M&O 1998b, p. II-2.

^b Holman 1997, p. 646.

5.1.7 Average Initial Linear Heat Loads

Average initial linear heat loads used for the emplacement drifts for the total waste package inventory are 1.0 kW/m and 1.45 kW/m. These values are used as part of a parametric study in this calculation.

5.1.8 Emplacement Drift Diameter and Drift Spacing

The emplacement drifts have a diameter of 5.5 m and a center-to-center spacing of 81 m (CRWMS M&O 2000d, Sections 2.3.1, p. 28). As part of a parametric study, drift spacings of 25 m and 40.5 m are also used in the calculation.

5.2 THEORETICAL BACKGROUND

Heat transfer mechanisms in a ventilated emplacement drift containing waste packages involve conduction, radiation, and convection. Conductive heat flow occurs within the waste package,

drip shield, invert, backfill material, and rock whenever there is a thermal gradient. Convective heat transfer occurs between the waste package surface and the ventilating air as well as between the drift wall and the air. Electromagnetic radiation heat transfer occurs directly between the waste package surface and the drift wall, and this is the predominant heat flow mode in emplacement drifts for this case. The radiation can transfer heat between two surfaces with a thermal gradient without going through a medium.

5.2.1 Conduction

According to the balance of thermal energy, the general 2D heat conduction equation (Fourier's law of heat conduction) for a drift can be expressed in Cartesian coordinates as (Holman 1997, Equation 1-3, p. 5):

$$\frac{\partial}{\partial x} \left(k \frac{\partial T}{\partial x} \right) + \frac{\partial}{\partial y} \left(k \frac{\partial T}{\partial y} \right) + q''' = \rho c \frac{\partial T}{\partial t} \quad (\text{Eq. 5-1})$$

where	T	=	temperature, K
	t	=	time, s
	k	=	thermal conductivity, W/m·K
	ρ	=	density, kg/m ³
	q'''	=	heat generation rate per unit volume, W/m ³
	c	=	specific heat, J/kg·K

5.2.2 Convection

For an air-ventilated drift, the overall effect of convection can be evaluated using Newton's law of cooling (Holman 1997, Equation 1-8, p. 12):

$$q = hA(T_w - T_a) \quad (\text{Eq. 5-2})$$

Where	q	=	heat flow rate, W
	h	=	convection heat transfer coefficient, W/m ² ·K
	A	=	convection surface area, m ²
	T_w	=	drift wall or waste package surface temperature, K
	T_a	=	ventilation air temperature, K

5.2.3 Radiation

The heat from the waste packages to the drip shield or drift wall is transferred mainly through thermal radiation. In the calculations, it is assumed that the waste packages are completely enclosed the drift wall. Therefore, the total radiant exchange can be calculated using the following equation based on the Stefan–Boltzmann law (Holman 1997, Equation 1-11, p. 14):

$$q = F_e F_G \sigma A (T_p^4 - T_w^4) \quad (\text{Eq. 5-3})$$

where	q	=	heat flow rate, W
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F_ϵ	=	emissivity function, dimensionless
F_G	=	geometric view factor function, dimensionless
σ	=	Stefan-Boltzmann constant with a value of $5.669 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4$
A	=	radiation surface area, m^2
T_p	=	absolute temperature of the waste package surface, K
T_w	=	absolute temperature of the drift wall, K

5.3 CALCULATION APPROACH

5.3.1 Model Configurations

Figure 5-1 illustrates the configuration of ANSYS model. This configuration contains all the rock units listed in Table 5-1 of Section 5.1.3, so the vertical dimension is 606.57 m. For simplicity of this sensitivity study, the waste package is placed at the center of an emplacement drift, as shown in Figure 5.1. Due to the thermal symmetry, only half of the drift spacing is used for the horizontal dimension. The diameters of the drift and waste package are 5.5 m (Section 5.1.8) and 1.564 m (Section 5.1.5.4), respectively.

5.3.2 Initial and Boundary Conditions

Initial rock temperature at the emplacement drift horizon is calculated using the in-situ rock thermal gradient provided in Section 3.2 as follows:

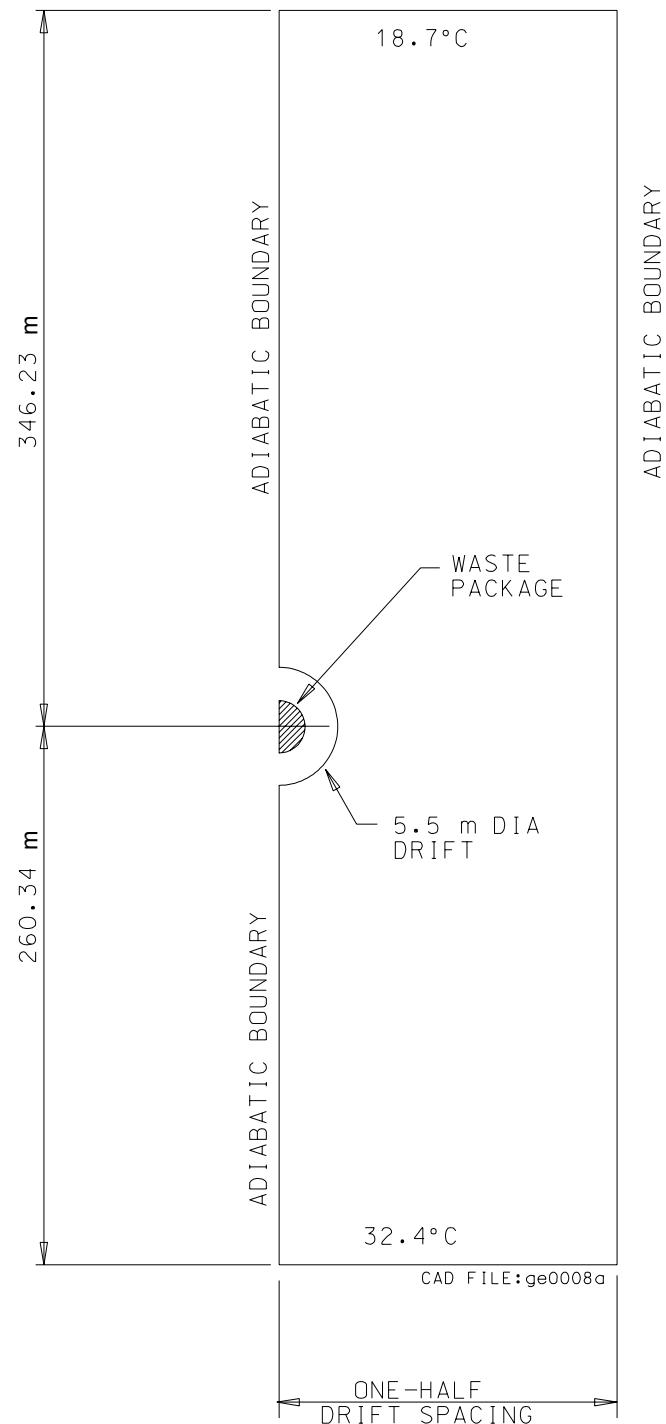
$$18.7 + (150)(0.020) + (346.23 - 150)(0.018) = 25.23^\circ\text{C} \approx 25^\circ\text{C}$$

The inlet air temperature for ventilation is set to be equal to the initial rock temperature of 25°C .

Constant temperatures are set on both the upper and lower boundaries of the model, as indicated in Figure 5.1. These boundary temperatures are determined based on Section 3.2. The temperature of 32.4°C on the lower boundary is calculated based on the temperature on the surface, 18.7°C , and the rock thermal gradient provided in Section 3.2 as follows:

$$18.7 + (150)(0.020) + (400 - 150)(0.018) + (606.57 - 400)(0.030) = 32.4^\circ\text{C}$$

Due to thermal symmetry, both lateral boundaries of the models are set to be adiabatic, meaning that no heat will flow into or out of the lateral boundaries.



NOT TO SCALE

Figure 5-1. Dimensions and Boundary Conditions of ANSYS Model

5.3.3 Approach

5.3.3.1 Modeling of Forced or Natural Ventilation

Determination of heat exchange in a ventilated drift is a complex three-dimensional and time-dependent problem. To simplify the solution, an approximate numerical approach using the ANSYS computer code is employed. A description of the approach follows:

First, an emplacement drift, subjected to continuous ventilation, with a length of L (see Section 3.5 for effective length of air flow) is divided into a finite number of drift segments of equal length Δl , so the total number of drift segments, m , will be equal to $L/\Delta l$. During modeling, the drift segments are treated as a series of connected elements, and the exit air temperature at a segment is used as an intake air temperature for the subsequent segment. The ventilating air, wall, and waste package temperatures at a specific modeling time are assumed to be constant over the length of a drift segment. Theoretically, the length of drift segments should be selected as short as possible so that the changing air, wall, and waste package surface temperatures along a drift segment can be reasonably represented by their averaged constants. But practically, a relatively long drift segment (100 meters) used in the calculation can be justified as long as overall accuracy of the models is not compromised.

The computation for temperatures is performed for every drift segment sequentially over a prespecified ventilation time or duration, t_{vent} , so the total number of computational runs for each case is the same as that of the drift division, m . In this calculation, the 600-meter-long drift was divided into six (6) segments, with a length of 100 meters for each segment.

Second, the ventilation time, t_{vent} , is partitioned into a number of time-steps, n , for each computational run. The size of each time-step, Δt_i , $i=1,2,\dots,n$, is determined based on experience regarding the degree of computational accuracy because it is assumed that the ventilating air temperature in a drift segment is constant over each time-step and the heat decay of waste packages in the emplacement drifts varies linearly over the same time-step. Two factors are considered when determining the time-step size, Δt_i , $i=1,2,\dots,n$. One is the heat generation rate of waste packages in the emplacement drifts because the heat generated by waste packages varies with time. Initially, more heat may be generated and transferred to the rock mass. With time, the heat decay rate will drop, and less heat will be generated. Therefore, a small time-step is required at the beginning and a relatively larger time-step can be justified for the later time period. The other factor considered is the air temperature variation with time, which plays a more important role in selecting the size of time-steps. In this calculation, the size of time-steps selected varies from 1 year to 50 years for a modeling time of up to 500 years (duration of forced plus natural ventilation).

Third, after the selection of segment length and time-step size, the ANSYS program is executed sequentially for a total number of m times for each case. Resulting wall temperatures for the currently modeled drift segment are utilized to calculate the average exhaust air temperatures of the segment by means of Newton's cooling law (Equation 5-2). These exhaust air temperatures are then used as inputs for the ventilating intake air temperatures of the computational run for the subsequent drift segment. This process is repeated until the computational run for the last drift segment is completed.

The approach described above is applicable to all cases analyzed in this calculation. In addition, the effect of convection on waste package surface temperatures is also considered. To do so, the third step of the approach is modified to include the resulting waste package surface temperatures in calculating the average exhaust air temperatures. The following outlines the process of using Newton's cooling law (Equation 5-2) and energy balance (Equation 5-1) to calculate the exhaust air temperatures and the rates of heat removal in a drift segment.

The rates of heat removed from drift wall and waste package surface in a drift segment by ventilation are determined by:

$$q_w = hA_w(T_{wa} - T_{ain}) \quad (\text{Eq. 5-4})$$

and

$$q_p = hA_p(T_{pa} - T_{ain}) \quad (\text{Eq. 5-5})$$

where

q_w	=	rate of heat removed from drift wall, W
q_p	=	rate of heat removed from waste package surface, W
h	=	convection heat transfer coefficient, $\text{W}/\text{m}^2 \cdot \text{K}$
A_w	=	drift wall area, m^2
A_p	=	waste package surface area, m^2
T_{wa}	=	average drift wall temperature, K
T_{pa}	=	average waste package surface temperature, K
T_{ain}	=	intake air temperature, K

The exhaust air temperature is calculated based on Holman (1997, Equation 6-1, p. 286) as

$$T_{aout} = T_{ain} + \frac{q_w + q_p}{Q\rho c} \quad (\text{Eq. 5-6})$$

where

T_{aout}	=	exhaust air temperature, K
T_{ain}	=	intake air temperature, K
q_w	=	rate of heat removed from drift wall, W
q_p	=	rate of heat removed from waste package surface, W
Q	=	ventilation air flow rate, m^3/s
ρ	=	density of air, kg/m^3
c	=	specific heat of air, $\text{J}/\text{kg} \cdot \text{K}$

Then substitute the average of the intake and exhaust air temperatures for the intake air temperature, T_{ain} , in Equations (5-4) and (5-5), to calculate the rates of heat removed by ventilation at a given time step, that is,

$$q_{rm} = \bar{q}_w + \bar{q}_p = hA_w(T_{wa} - T_{aa}) + hA_p(T_{pa} - T_{aa}) \quad (\text{Eq. 5-7})$$

where

T_{aa}	=	average of intake and exhaust air temperature in a drift segment at
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a given time step, K, defined as

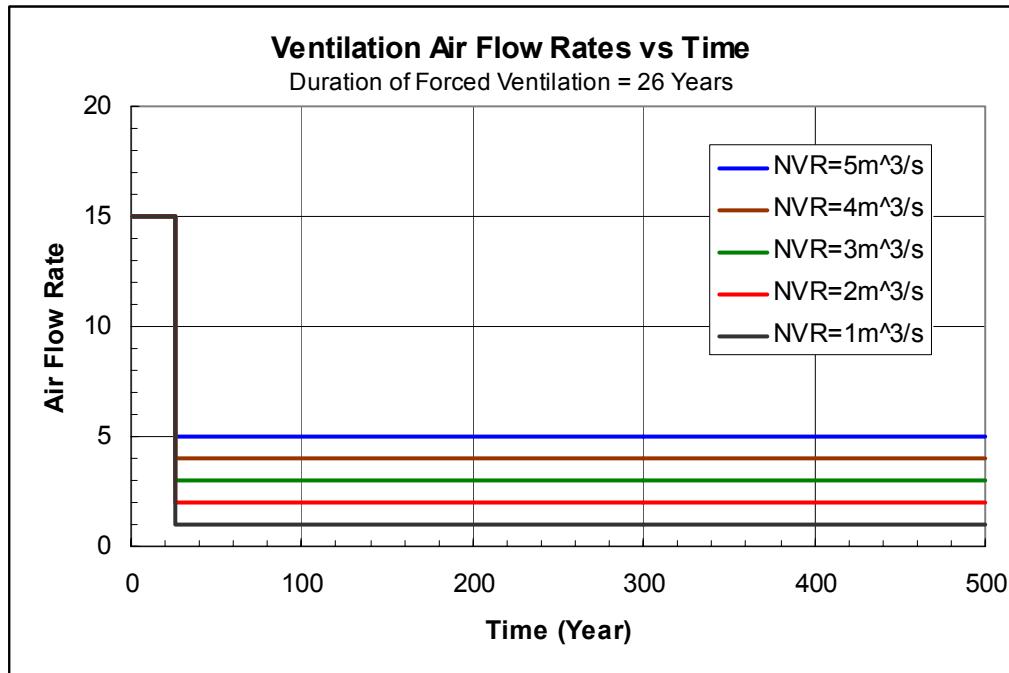
$$T_{aa} = \frac{T_{ain} + T_{aout}}{2} \quad (\text{Eq. 5-8})$$

where T_{ain} = intake air temperature, K
 T_{aout} = exhaust air temperature, K

5.3.3.2 Ventilating Air Flow Rates and Duration

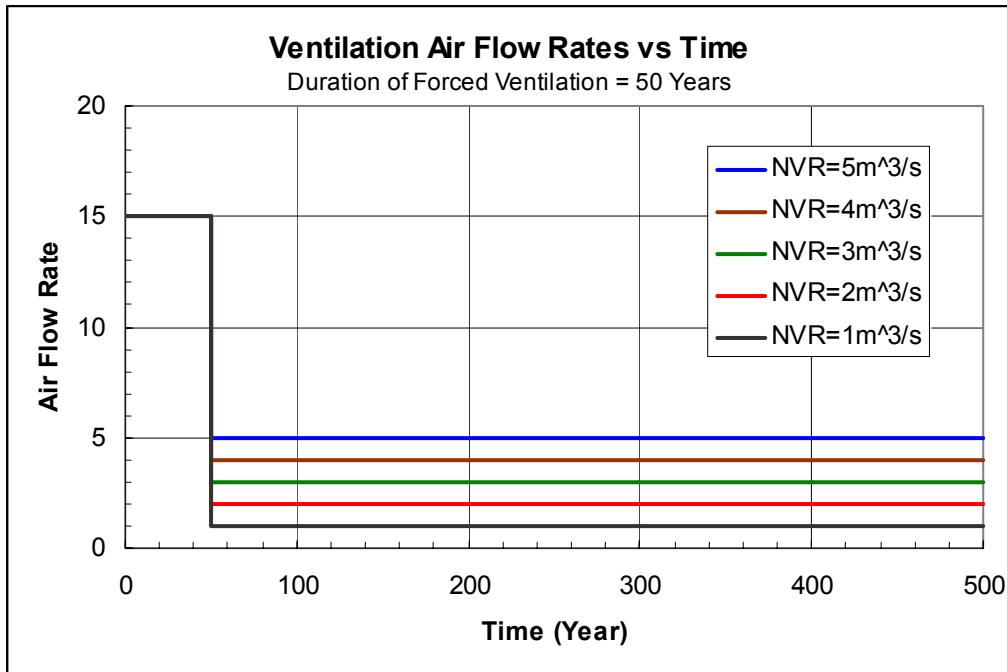
Forced ventilation with a constant air flow rate of $15 \text{ m}^3/\text{s}$ is modeled for the preclosure periods of 26, 50, and 75 years (Section 5.1.9). Natural ventilation is modeled with air flow rates of 1, 1.5, 2, 2.5, 3, 4, and $5 \text{ m}^3/\text{s}$ for duration of 300 years and 500 years less the preclosure period, 26, 50, or 75 years (Section 5.1.9).

Two scenarios are analyzed for the natural ventilation: (a) the air flow rate is kept constant over the natural ventilation period: 500 years less the preclosure periods; and (b) the air flow rate is constant over two sub-periods of natural ventilation: from 50-year to 100-year and from 100-year to 300-year. Figures 5-2 through 5-5 illustrate variations of the ventilation air flow rates versus the ventilation duration for different cases analyzed.



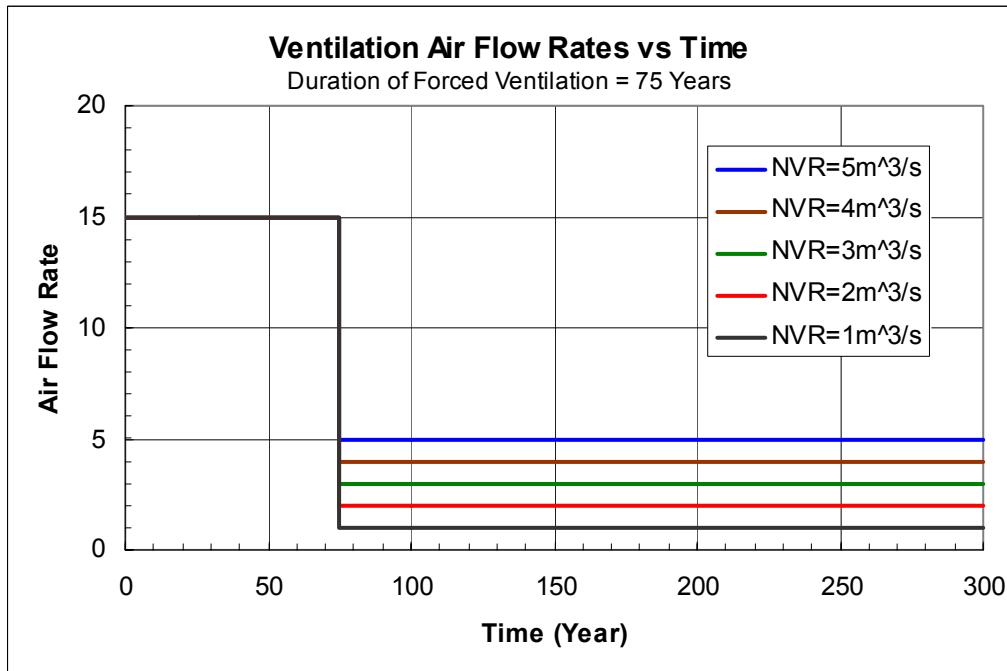
Note: NVR=Natural Ventilation Air Flow Rate

Figure 5-2. Ventilation Air Flow Rates versus Time for a Preclosure Period of 26 Years



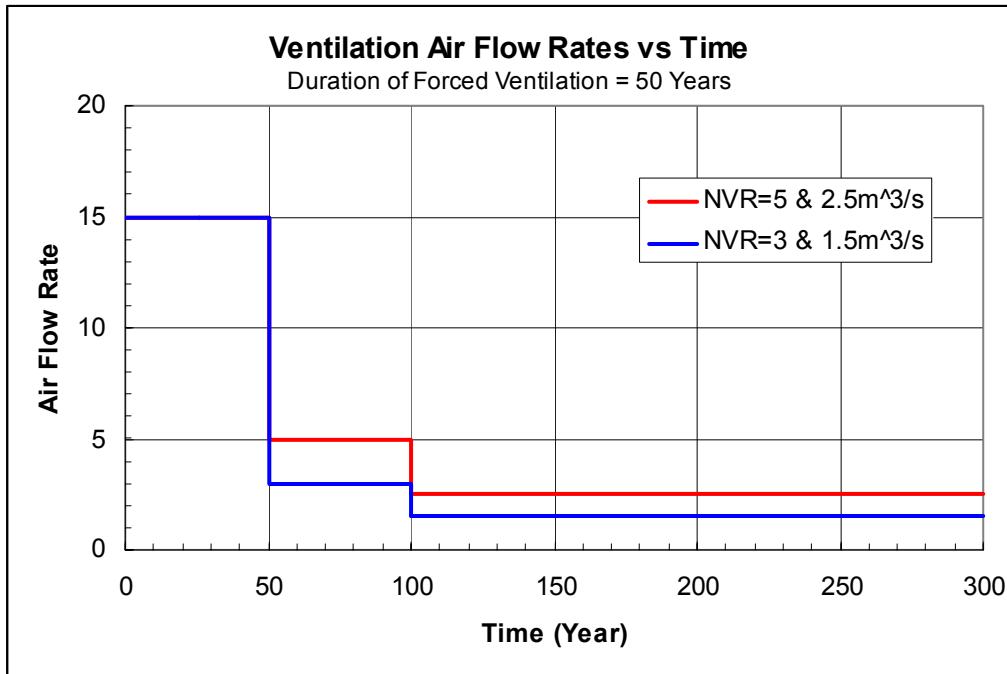
Note: NVR=Natural Ventilation Air Flow Rate

Figure 5-3. Ventilation Air Flow Rates versus Time for a Preclosure Period of 50 Years



Note: NVR=Natural Ventilation Air Flow Rate

Figure 5-4. Ventilation Air Flow Rates versus Time for a Preclosure Period of 75 Years



Note: NVR=Natural Ventilation Air Flow Rate

Figure 5-5. Ventilation Air Flow Rates versus Time for a Preclosure Period of 50 Years

5.3.3.3 Calculation of Convection Heat Transfer Coefficient

As stated, an air flow rate of 15 m³/s is considered for the forced ventilation (Sections 5.1.9 and 5.3.3.2), and the flow rates of 1, 1.5, 2, 2.5, 3, 4, and 5 m³/s are used for the natural ventilation (Sections 5.1.9 and 5.3.3.2). These flow rates are used to determine the convection heat transfer coefficients, as given in Table 5-8, for the thermal models. The following equations were employed in calculating the convection heat transfer coefficients:

Air flow velocity, v , based on *Fluid Mechanics* (White 1986, Equation 1.21, p. 16):

$$v = \frac{Q}{A} \quad (\text{Eq. 5-9})$$

where Q = ventilation air flow rate, m³/s
 A = cross-sectional area, m²

Reynolds No., Re (Holman 1997, Equation 5-2, p. 220):

$$Re = \frac{\rho v D_h}{\mu} \quad (\text{Eq. 5-10})$$

where ρ = density, kg/m³
 v = air flow velocity, m/s

$$\begin{aligned} D_h &= \text{hydraulic diameter of the cross section, m} \\ \mu &= \text{dynamic viscosity, kg/m·s} \end{aligned}$$

Nusselt No., Nu (Holman 1997, Equation 6-4a, p. 286; n=0.4 for heating, p. 286):

$$Nu = 0.023 Re^{0.8} Pr^{0.4} \quad (\text{Eq. 5-11})$$

where Re = Reynolds number, dimensionless
 Pr = Prandtl number, dimensionless

The expression (5-11) is for calculation of heat transfer in fully developed turbulent flow in smooth tubes, and considered applicable for this calculation.

Convection heat transfer coefficient, h (Holman 1997, Equation 5-107, p. 261):

$$h = \frac{kNu}{D_h} \quad (\text{Eq. 5-12})$$

where k = thermal conductivity, W/m·K
 Nu = Nusselt Number, dimensionless
 D_h = hydraulic diameter of the cross section, m

Table 5-8 summarizes the results of calculation of the convection heat transfer coefficients for the air flow rates of 1 to 15 m³/s. The values of air properties, such as density, thermal conductivity, specific heat, dynamic viscosity, and Prandtl number, used to calculate the convection heat transfer coefficients are given in Table 5-7, Section 5.1.6.

Table 5-8. Convection Heat Transfer Coefficients for Ventilation Modeling

Parameter	Value							
Air Flow Rate (m ³ /s)	15	5	4	3	2.5	2	1.5	1
Hydraulic Diameter (m)	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94
Cross-sectional Area (m ²)	21.84	21.84	21.84	21.84	21.84	21.84	21.84	21.84
Air Flow Velocity (m/s)	0.69	0.23	0.18	0.14	0.11	0.09	0.07	0.05
Reynolds No.	155493	51831	41465	31099	25916	20732	15549	10366
Nusselt No.	285.34	118.48	99.11	78.74	68.05	56.93	45.22	32.70
Convection Heat Transfer Coefficient (W/m ² ·K)	1.89	0.79	0.66	0.52	0.45	0.38	0.30	0.22

5.3.3.4 Heat Decay Values of Waste Packages

The heat decay values of waste packages used in the calculation are in the form of volumetric heat generation rates (watts per unit volume). These volumetric heat generation rates are calculated based on the initial linear heat loads, the average percentage values of initial heat, and the waste package volume. These values are used when the convection on waste package surface is considered in the models because a convection boundary instead of a heat flux boundary is prescribed on the waste package surface. It is noted that the values of volumetric heat generation rate are converted to a unit for time in years by multiplying a conversion factor of 3.1536×10^7 , which is the total number of seconds per year ($365 \text{ days/year} \times 24 \text{ hours/day} \times 3600 \text{ seconds/hour} = 3.1536 \times 10^7 \text{ seconds/year}$).

As part of the parametric study, two initial heat densities, 1.0 kW/m and 1.45 kW/m , are used. In addition, a case with additional 18 years of waste aging is modeled. To analyze this case, the decay values of waste is set to be equal to those at 18 years older for other cases without additional waste aging, that is:

$$P_{w/\text{aging}}(t) = P_{w/o\text{aging}}(t+18) \quad (\text{Eq. 5-13})$$

where $P_{w/\text{aging}}$ = heat power of waste with additional aging, kW/package
 $P_{w/o\text{aging}}$ = heat power of waste without additional aging, kW/package
 t = time, year

Figure 5-6 illustrates the heat decay curve for waste with additional 18 years of aging in the form of volumetric heat density (heat generation rate), compared with that for waste without additional aging. It is seen that the aging curve is obtained by moving the non-aging curve to the left by 18 years. Details of the calculation of the volumetric heat generation rates are presented in Attachment I.

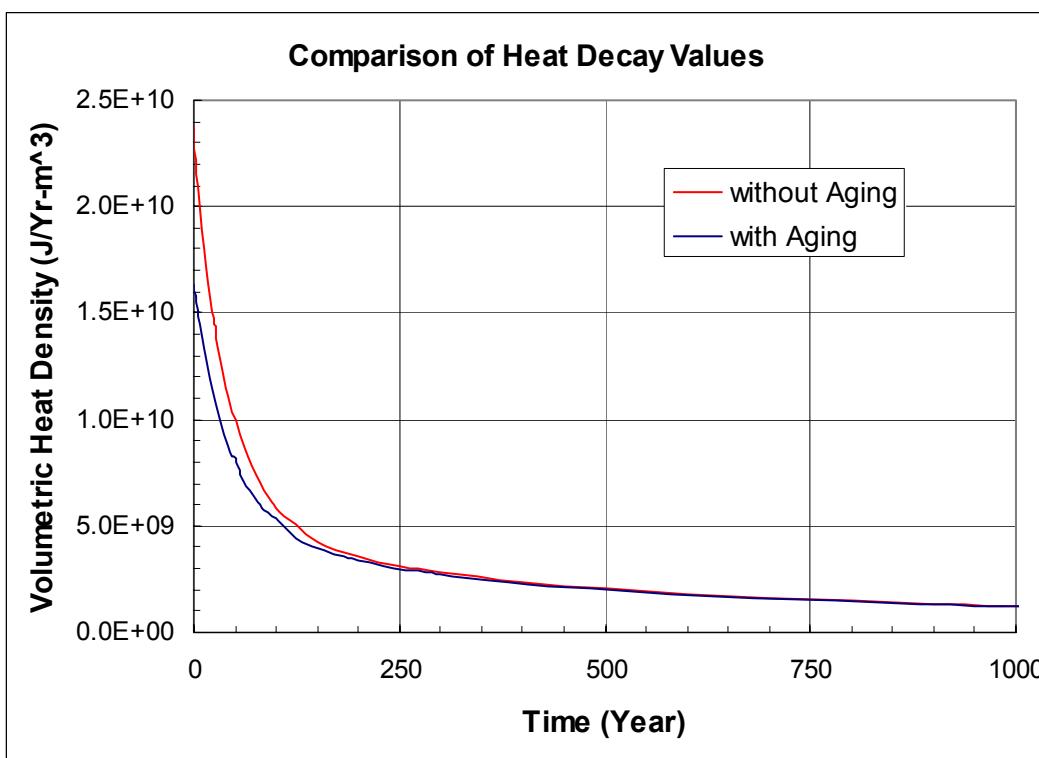


Figure 5-6. Comparison of Heat Decay Values for Waste with or without Additional Aging

6. RESULTS

This section summarizes the results of the calculation (DTNs: MO0010MWDANS03.005 and MO0103MWDTEM00.007). Some of the input data used are unqualified, therefore, the confirmation of these unqualified data is required prior to the use of the results of the calculation for procurement, fabrication, or construction.

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6.1. NUMERICAL CASES ANALYZED

There are twenty-five (25) different cases analyzed as part of parametric study in this calculation. Variations of the following parameters are considered: duration of forced ventilation, rate of natural ventilation, linear heat load or density, drift spacing, thermal conductivity, and waste age. Table 6-1 provides a list of all cases analyzed as well as the brief case descriptions.

6.2 TEMPERATURES

6.2.1 Ventilation Air Temperatures

Ventilation air temperatures at different drift segments for various cases are presented in Attachments II through XXVI. A summary of the peak ventilation air temperatures is provided in Table 6-2.

6.2.2 Drift Wall Temperatures

Average drift wall temperatures and temperature difference across the drift length for various cases are presented in Attachments II through XXVI. The peak drift wall temperatures during both the forced and natural ventilation for various cases are summarized in Table 6-3. The peak drift wall temperatures after ventilation for various cases are summarized in Table 6-4.

6.2.3 Waste Package Surface Temperatures

Average waste package surface temperatures and temperature difference across the drift length for various cases are presented in Attachments II through XXVI. The peak waste package surface temperatures during both the forced and natural ventilation for various cases are summarized in Table 6-5. The peak waste package surface temperatures after ventilation for various cases are summarized in Table 6-6.

6.3 EFFICIENCY OF VENTILATION

Heat removal rates by both forced and natural ventilation are calculated using the approach discussed in Section 5.3.3.1, and presented in Attachments II through XXVI for various cases

considered. The efficiency of ventilation on heat management is judged by comparing the amount of total heat removed by ventilation over a given period to the amount of total heat generated by waste packages, that is:

$$\text{Efficiency of ventilation (\%)} = \frac{\text{Total heat removed}}{\text{Total heat generated}} \quad (\text{Eq. 6-1})$$

Table 6-7 summarizes the ventilation efficiency or heat removal by percentages in a 600-meter-long drift during ventilation. Additional information on the heat removal by drift segment is presented in Attachments II through XXVI.

6.4 EFFECTS OF DRIFT SPACING CHANGE ON TEMPERATURES

Three different drift spacings, 81 m, 40.5 m, and 25 m, are used as part of the sensitivity study to examine the effects of drift spacing change on temperatures. For drift spacings of 81 m and 40.5 m, both initial linear heat loads of 1.0 kW/m and 1.45 kW/m are used, while for a drift spacing of 25 m, the initial linear heat load considered is 1.45 kW/m. The results are presented in Attachments II through XVIII and XXIII through XXVI for cases with a drift spacing of 81 m, in Attachments XIX through XXI for cases with a drift spacing of 40.5 m, and in Attachment XXII for a case with a drift spacing of 25 m. The peak drift wall and waste package surface temperatures for the corresponding cases with different drift spacings are compared in Table 6-8.

6.5 EFFECT OF THERMAL CONDUCTIVITY CHANGE ON TEMPERATURES

To examine the effects of uncertainties of thermal conductivity values for stratigraphic units on temperatures, their values are reduced or raised by 25 percent in two cases (Case IDs: HF5N5V8KD and HF5N5V8KU). The initial linear heat load used for these two cases is 1.45 kW/m. The results are presented in Attachments XXIII and XXIV. The peak drift wall and waste package surface temperatures for the corresponding cases with different thermal conductivity values are compared in Table 6-9. Figures 6-1 and 6-2 illustrate the time histories of drift wall and waste package surface temperatures, respectively, for cases with various thermal conductivity values.

6.6 EFFECT OF WASTE AGING ON TEMPERATURES

A case with additional 18 years of waste aging is calculated to examine the effects of waste aging on temperatures. The effective initial linear heat load after additional 18 years of waste aging is 1.0 kW/m, compared to that of 1.45 kW/m without additional waste aging. The results for this case is presented in Attachment XXV. The peak drift wall and waste package surface temperatures for the following three corresponding cases: HF5N5V8, LF5N5V8, and HF5N5V8A are summarized in Table 6-10. Figures 6-3 and 6-4 compare the time histories of drift wall and waste package surface temperatures for these three cases, respectively.

6.7 IN-DRIFT RELATIVE HUMIDITY

The in-drift relative humidity is calculated for the case 25: HF5N3VI8. As noted in Table 6-1, natural ventilation is considered for up to 10,000 years. The time histories of drift wall and

waste package temperatures and in-drift relative humidity for the case 25: HF5N3VI8 are shown in Figure 6-5. Details on the calculation of in-drift relative humidity for this case are presented in Attachment XXVII.

Table 6-1. Identifications and Descriptions of Cases Analyzed

Case Count	Case ID	Case Description
01	HF2N1C8	Initial linear heat load=1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–26 years), air flow rate of natural ventilation=1m ³ /s (26–500 years), drift spacing=81m.
02	HF2N2C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–26 years), air flow rate of natural ventilation=2m ³ /s (26–500 years), drift spacing=81m.
03	HF2N3C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–26 years), air flow rate of natural ventilation=3m ³ /s (26–500 years), drift spacing=81m.
04	HF2N4C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–26 years), air flow rate of natural ventilation=4m ³ /s (26–500 years), drift spacing=81m.
05	HF2N5C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–26 years), air flow rate of natural ventilation=5m ³ /s (26–500 years), drift spacing=81m.
06	HF5N1C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=1m ³ /s (50–500 years), drift spacing=81m.
07	HF5N2C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=2m ³ /s (50–500 years), drift spacing=81m.
08	HF5N3C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=3m ³ /s (50–500 years), drift spacing=81m.
09	HF5N4C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=4m ³ /s (50–500 years), drift spacing=81m.
10	HF5N5C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–26 years), air flow rate of natural ventilation=5m ³ /s (50–500 years), drift spacing=81m.
11	HF7N1C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–75 years), air flow rate of natural ventilation=1m ³ /s (75–500 years), drift spacing=81m.
12	HF7N3C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–75 years), air flow rate of natural ventilation=3m ³ /s (75–500 years), drift spacing=81m.
13	HF7N5C8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–75 years), air flow rate of natural ventilation=5m ³ /s (75–500 years), drift spacing=81m.
14	HF5N3V8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation =15m ³ /s (0–50 years), air flow rate of natural ventilation =3m ³ /s (50–100 years) and 1.5m ³ /s (100–300 years), drift spacing=81m.
15	HF5N5V8	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation =15m ³ /s (0–50 years), air flow rate of natural ventilation =5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=81m.
16	LF5N3V8	Initial linear heat load =1.0kW/m, air flow rate of forced ventilation=15 m ³ /s (0–50 years), air flow rate of natural ventilation =3m ³ /s (50–100 years) and 1.5m ³ /s (100–300 years), drift spacing=81m.
17	LF5N5V8	Initial linear heat load =1.0kW/m, air flow rate of forced ventilation=15 m ³ /s (0–50 years), air flow rate of natural ventilation =5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=81m.
18	HF5N5V4	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15 m ³ /s (0–50 years), air flow rate of natural ventilation =5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=40.5m.
19	LF5N3V4	Initial linear heat load =1.0kW/m, air flow rate of forced ventilation=15 m ³ /s (0–50 years), air flow rate of natural ventilation =3m ³ /s (50–100 years) and 1.5m ³ /s (100–300 years), drift spacing=40.5m.
20	LF5N5V4	Initial linear heat load =1.0kW/m, air flow rate of forced ventilation=15 m ³ /s (0–50 years), air flow rate of natural ventilation =5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=40.5m.
21	HF5N5V2	Initial linear heat load =1.45 kW/m, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=25m.
22	HF5N5V8KD	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=81m, thermal conductivity values reduced by 25%.
23	HF5N5V8KU	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=81m, thermal conductivity values increased by 25%.
24	HF5N5V8A	Initial linear heat load =1.0kW/m by 18 years of additional aging, air flow rate of forced ventilation=15m ³ /s (0–50 years), air flow rate of natural ventilation=5m ³ /s (50–100 years) and 2.5m ³ /s (100–300 years), drift spacing=81m.
25	HF5N3V18	Initial linear heat load =1.45kW/m, air flow rate of forced ventilation =15m ³ /s (0–50 years), air flow rate of natural ventilation =3m ³ /s (50–100 years), 1.5m ³ /s (100–300 years), and 1m ³ /s (300–10,000 years), drift spacing=81m.

Table 6-2. Summary of Peak Ventilation Air Temperatures during Ventilation for Various Cases

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak Air Temperature during Forced Ventilation (during Natural Ventilation) (°C)	Time to Reach during Forced Ventilation (during Natural Ventilation) (Year)	
01: HF2N1C8	1.45	15 (0-26Yrs)	1 (26-500Yrs)	81	61 (141)	10 (60)	
02: HF2N2C8			2 (26-500Yrs)		61 (111)	10 (50)	
03: HF2N3C8			3 (26-500Yrs)		61 (94)	10 (50)	
04: HF2N4C8			4 (26-500Yrs)		61 (84)	10 (50)	
05: HF2N5C8			5 (26-500Yrs)		61 (76)	10 (50)	
06: HF5N1C8		15 (0-50Yrs)	1 (50-500Yrs)		61 (105)	10 (90)	
07: HF5N2C8			2 (50-500Yrs)		61 (86)	10 (80)	
08: HF5N3C8			3 (50-500Yrs)		61 (75)	10 (80)	
09: HF5N4C8			4 (50-500Yrs)		61 (67)	10 (80)	
10: HF5N5C8			5 (50-500Yrs)		61 (62)	10 (80)	
11: HF7N1C8		15 (0-75Yrs)	1 (75-300Yrs)		61 (90)	10 (125)	
12: HF7N3C8			3 (75-300Yrs)		61 (66)	10 (100)	
13: HF7N5C8			5 (75-300Yrs)		61 (55)	10 (100)	
14: HF5N3V8		1.0	3 (50-100Yrs) & 1.5 (100-300Yrs)		61 (77)	10 (150)	
15: HF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)		61 (64)	10 (150)	
16: LF5N3V8			3 (50-100Yrs) & 1.5 (100-300Yrs)		50 (61)	10 (150)	
17: LF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)		50 (52)	10 (150)	
18: HF5N5V4	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	40.5	62 (69)	10 (150)	
19: LF5N3V4	1.0		3 (50-100Yrs) & 1.5 (100-300Yrs)		50 (68)	10 (150)	
20: LF5N5V4			5 (50-100Yrs) & 2.5 (100-300Yrs)		50 (55)	10 (150)	
21: HF5N5V2	1.45		5 (50-100Yrs) & 2.5 (100-300Yrs)	25	63 (72)	10 (150)	
22: HF5N5V8KD ^a			5 (50-100Yrs) & 2.5 (100-300Yrs)	81	63 (66)	10 (150)	
23: HF5N5V8KU ^b			5 (50-100Yrs) & 2.5 (100-300Yrs)		60 (62)	10 (150)	
24: HF5N5V8A	1.0 ^c		5 (50-100Yrs) & 2.5 (100-300Yrs)		51 (61)	12 (132)	
25: HF5N3VI8	1.45		3 (50-100Yrs), 1.5 (100-300Yrs), & 1.0 (300-10,000Yrs)		61 (77)	10 (150)	

Note: ^a Thermal conductivity values reduced by 25 percent.

^b Thermal conductivity values raised by 25 percent.

^c Initial linear heat load with additional 18 years of waste aging.

Table 6-3. Summary of Peak Drift Wall Temperatures during Ventilation for Various Cases

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak Drift Wall Temperature during Forced Ventilation (during Natural Ventilation) (°C)	Time to Reach during Forced Ventilation (during Natural Ventilation) (Year)
01: HF2N1C8	1.45	15 (0-26Yrs)	1 (26-500Yrs)	81	72 (153)	10 (50)
02: HF2N2C8			2 (26-500Yrs)		72 (125)	10 (50)
03: HF2N3C8			3 (26-500Yrs)		72 (107)	10 (40)
04: HF2N4C8			4 (26-500Yrs)		72 (96)	10 (40)
05: HF2N5C8			5 (26-500Yrs)		72 (89)	10 (40)
06: HF5N1C8		15 (0-50Yrs)	1 (50-500Yrs)		72 (113)	10 (80)
07: HF5N2C8			2 (50-500Yrs)		72 (94)	10 (80)
08: HF5N3C8			3 (50-500Yrs)		72 (83)	10 (80)
09: HF5N4C8			4 (50-500Yrs)		72 (76)	10 (70)
10: HF5N5C8			5 (50-500Yrs)		72 (70)	10 (70)
11: HF7N1C8		15 (0-75Yrs)	1 (75-300Yrs)		72 (96)	10 (125)
12: HF7N3C8			3 (75-300Yrs)		72 (73)	10 (100)
13: HF7N5C8			5 (75-300Yrs)		72 (62)	10 (90)
14: HF5N3V8		1.0	3 (50-100Yrs) & 1.5 (100-300Yrs)		72 (84)	10 (125)
15: HF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)		72 (70)	10 (125)
16: LF5N3V8			3 (50-100Yrs) & 1.5 (100-300Yrs)		57 (66)	5 (125)
17: LF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)		57 (56)	5 (125)
18: HF5N5V4	1.45	1.0	5 (50-100Yrs) & 2.5 (100-300Yrs)	40.5	72 (78)	10 (150)
19: LF5N3V4	3 (50-100Yrs) & 1.5 (100-300Yrs)		57 (74)		10 (150)	
20: LF5N5V4	5 (50-100Yrs) & 2.5 (100-300Yrs)		57 (61)		10 (150)	
21: HF5N5V2	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	25	75 (83)	10 (150)
22: HF5N5V8KD ^a			5 (50-100Yrs) & 2.5 (100-300Yrs)	81	74 (73)	10 (125)
23: HF5N5V8KU ^b			5 (50-100Yrs) & 2.5 (100-300Yrs)		70 (68)	10 (70)
24: HF5N5V8A	1.0 ^c	1.45	5 (50-100Yrs) & 2.5 (100-300Yrs)		58 (67)	12 (132)
25: HF5N3VI8	1.45		3 (50-100Yrs), 1.5 (100-300Yrs), & 1.0 (300-10,000Yrs)		72 (84)	10 (125)

Note: ^a Thermal conductivity values reduced by 25 percent.

^b Thermal conductivity values raised by 25 percent.

^c Initial linear heat load with additional 18 years of waste aging.

Table 6-4. Summary of Peak Drift Wall Temperatures for Various Cases

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak Drift Wall Temperature (°C)	Time to Reach (Year)	
01: HF2N1C8	1.45	15 (0-26Yrs)	1 (26-500Yrs)	81	153 ^d	50	
02: HF2N2C8			2 (26-500Yrs)		125 ^d	50	
03: HF2N3C8			3 (26-500Yrs)		107 ^d	40	
04: HF2N4C8			4 (26-500Yrs)		96 ^d	40	
05: HF2N5C8			5 (26-500Yrs)		89 ^d	40	
06: HF5N1C8		15 (0-50Yrs)	1 (50-500Yrs)		113 ^d	80	
07: HF5N2C8			2 (50-500Yrs)		94 ^d	80	
08: HF5N3C8			3 (50-500Yrs)		83 ^d	80	
09: HF5N4C8			4 (50-500Yrs)		76 ^d	70	
10: HF5N5C8			5 (50-500Yrs)		70 ^d	70	
11: HF7N1C8		15 (0-75Yrs)	1 (75-300Yrs)		96 ^d	125	
12: HF7N3C8			3 (75-300Yrs)		73 ^d	100	
13: HF7N5C8			5 (75-300Yrs)		62 ^d	90	
14: HF5N3V8	1.0	3 (50-100Yrs) & 1.5 (100-300Yrs)	81	40.5	98	668	
15: HF5N5V8					94	728	
16: LF5N3V8		3 (50-100Yrs) & 1.5 (100-300Yrs)			76	648	
17: LF5N5V8		5 (50-100Yrs) & 2.5 (100-300Yrs)			73	768	
18: HF5N5V4	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	25	136	970	
19: LF5N3V4	1.0		3 (50-100Yrs) & 1.5 (100-300Yrs)		111	1113	
20: LF5N5V4			5 (50-100Yrs) & 2.5 (100-300Yrs)		107	1210	
21: HF5N5V2	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	81	187	1333	
22: HF5N5V8KD ^a			5 (50-100Yrs) & 2.5 (100-300Yrs)		107	717	
23: HF5N5V8KU ^b			5 (50-100Yrs) & 2.5 (100-300Yrs)		88	748	
24: HF5N5V8A	1.0 ^c	1.45	5 (50-100Yrs) & 2.5 (100-300Yrs)	81	92	710	
25: HF5N3VI8	1.45		3 (50-100Yrs), 1.5 (100-300Yrs), & 1.0 (300-10,000Yrs)		84	125	

Note: ^a Thermal conductivity values reduced by 25 percent.

^b Thermal conductivity values raised by 25 percent.

^c Initial linear heat load with additional 18 years of waste aging.

^d Occurred during natural ventilation since post-ventilation is not analyzed.

Table 6-5. Summary of Peak Waste Package Surface Temperatures during Ventilation for Various Cases

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak WP Surface Temperature during Forced Ventilation (during Natural Ventilation) (°C)	Time to Reach during Forced Ventilation (during Natural Ventilation) (Year)
01: HF2N1C8	1.45	15 (0-26Yrs)	1 (26-500Yrs)	81	94 (162)	5 (50)
02: HF2N2C8			2 (26-500Yrs)		94 (134)	5 (50)
03: HF2N3C8			3 (26-500Yrs)		94 (119)	5 (40)
04: HF2N4C8			4 (26-500Yrs)		94 (109)	5 (40)
05: HF2N5C8			5 (26-500Yrs)		94 (102)	5 (40)
06: HF5N1C8		15 (0-50Yrs)	1 (50-500Yrs)		94 (121)	5 (80)
07: HF5N2C8			2 (50-500Yrs)		94 (103)	5 (80)
08: HF5N3C8			3 (50-500Yrs)		94 (93)	5 (70)
09: HF5N4C8			4 (50-500Yrs)		94 (86)	5 (70)
10: HF5N5C8			5 (50-500Yrs)		94 (81)	5 (70)
11: HF7N1C8		15 (0-75Yrs)	1 (75-300Yrs)		94 (103)	5 (100)
12: HF7N3C8			3 (75-300Yrs)		94 (81)	5 (100)
13: HF7N5C8			5 (75-300Yrs)		94 (71)	5 (90)
14: HF5N3V8		1.0	3 (50-100Yrs) & 1.5 (100-300Yrs)		94 (93)	5 (70)
15: HF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)		94 (81)	5 (70)
16: LF5N3V8			3 (50-100Yrs) & 1.5 (100-300Yrs)		75 (73)	5 (70)
17: LF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)		75 (64)	5 (70)
18: HF5N5V4	1.45	1.0	5 (50-100Yrs) & 2.5 (100-300Yrs)	40.5	94 (84)	5 (70)
19: LF5N3V4	3 (50-100Yrs) & 1.5 (100-300Yrs)		75 (79)		5 (150)	
20: LF5N5V4	5 (50-100Yrs) & 2.5 (100-300Yrs)		75 (66)		5 (70)	
21: HF5N5V2	1.45	5 (50-100Yrs) & 2.5 (100-300Yrs)	25	95 (88)	5 (150)	
22: HF5N5V8KD ^a		5 (50-100Yrs) & 2.5 (100-300Yrs)	81	96 (83)	5 (70)	
23: HF5N5V8KU ^b		5 (50-100Yrs) & 2.5 (100-300Yrs)		93 (79)	5 (70)	
24: HF5N5V8A	1.0 ^c	1.45		5 (50-100Yrs) & 2.5 (100-300Yrs)	75 (74)	7 (107)
25: HF5N3VI8	1.45			3 (50-100Yrs), 1.5 (100-300Yrs), & 1.0 (300-10,000Yrs)	94 (93)	5 (70)

Note: ^a Thermal conductivity values reduced by 25 percent.

^b Thermal conductivity values raised by 25 percent.

^c Initial linear heat load with additional 18 years of waste aging.

Table 6-6. Summary of Peak Waste Package Surface Temperatures for Various Cases

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak WP Surface Temperature (°C)	Time to Reach (Year)	
01: HF2N1C8	1.45	15 (0-26Yrs)	1 (26-500Yrs)	81	162 ^d	50	
02: HF2N2C8			2 (26-500Yrs)		134 ^d	50	
03: HF2N3C8			3 (26-500Yrs)		119 ^d	40	
04: HF2N4C8			4 (26-500Yrs)		109 ^d	40	
05: HF2N5C8			5 (26-500Yrs)		102 ^d	40	
06: HF5N1C8		15 (0-50Yrs)	1 (50-500Yrs)		121 ^d	80	
07: HF5N2C8			2 (50-500Yrs)		103 ^d	80	
08: HF5N3C8			3 (50-500Yrs)		93 ^d	70	
09: HF5N4C8			4 (50-500Yrs)		86 ^d	70	
10: HF5N5C8			5 (50-500Yrs)		81 ^d	70	
11: HF7N1C8		15 (0-75Yrs)	1 (75-300Yrs)		103 ^d	100	
12: HF7N3C8			3 (75-300Yrs)		81 ^d	100	
13: HF7N5C8			5 (75-300Yrs)		71 ^d	90	
14: HF5N3V8	1.0	3 (50-100Yrs) & 1.5 (100-300Yrs)	81	40.5	101	563	
15: HF5N5V8					96	668	
16: LF5N3V8		3 (50-100Yrs) & 1.5 (100-300Yrs)			78	588	
17: LF5N5V8		5 (50-100Yrs) & 2.5 (100-300Yrs)			75	648	
18: HF5N5V4	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	25	138	950	
19: LF5N3V4	1.0		3 (50-100Yrs) & 1.5 (100-300Yrs)		112	910	
20: LF5N5V4			5 (50-100Yrs) & 2.5 (100-300Yrs)		108	1170	
21: HF5N5V2	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	81	188	1333	
22: HF5N5V8KD ^a			5 (50-100Yrs) & 2.5 (100-300Yrs)		109	668	
23: HF5N5V8KU ^b			5 (50-100Yrs) & 2.5 (100-300Yrs)		90	668	
24: HF5N5V8A	1.0 ^c	1.45	5 (50-100Yrs) & 2.5 (100-300Yrs)	81	94	690	
25: HF5N3VI8	1.45		3 (50-100Yrs), 1.5 (100-300Yrs), & 1.0 (300-10,000Yrs)		94	5	

Note: ^a Thermal conductivity values reduced by 25 percent.

^b Thermal conductivity values raised by 25 percent.

^c Initial linear heat load with additional 18 years of waste aging.

^d Occurred during natural ventilation since post-ventilation is not analyzed.

Table 6-7. Summary of Efficiency of Both Forced and Natural Ventilation for Various Cases

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Efficiency of Ventilation (% of Total Heat Removed for the Duration)		
					Forced Ventilation over 26, 50, or 75 Years	Forced plus Natural Ventilation over 300 Years	
01: HF2N1C8	1.45	15 (0-26Yrs)	1 (26-500Yrs)	81	66	43	
02: HF2N2C8			2 (26-500Yrs)			55	
03: HF2N3C8			3 (26-500Yrs)			62	
04: HF2N4C8			4 (26-500Yrs)			66	
05: HF2N5C8			5 (26-500Yrs)			70	
06: HF5N1C8		15 (0-50Yrs)	1 (50-500Yrs)		72	50	
07: HF5N2C8			2 (50-500Yrs)			60	
08: HF5N3C8			3 (50-500Yrs)			65	
09: HF5N4C8			4 (50-500Yrs)			69	
10: HF5N5C8			5 (50-500Yrs)			72	
11: HF7N1C8		15 (0-75Yrs)	1 (75-300Yrs)		75	55	
12: HF7N3C8			3 (75-300Yrs)			67	
13: HF7N5C8			5 (75-300Yrs)			73	
14: HF5N3V8		15 (0-50Yrs)	3 (50-100Yrs) & 1.5 (100-300Yrs)		72	57	
15: HF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)			64	
16: LF5N3V8			3 (50-100Yrs) & 1.5 (100-300Yrs)			58	
17: LF5N5V8			5 (50-100Yrs) & 2.5 (100-300Yrs)			65	
18: HF5N5V4	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	40.5	74	69	
19: LF5N3V4	1.0		3 (50-100Yrs) & 1.5 (100-300Yrs)		75	63	
20: LF5N5V4			5 (50-100Yrs) & 2.5 (100-300Yrs)			69	
21: HF5N5V2	1.45	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)	25	76	73	
22: HF5N5V8KD ^a			5 (50-100Yrs) & 2.5 (100-300Yrs)	81	72	64	
23: HF5N5V8KU ^b			5 (50-100Yrs) & 2.5 (100-300Yrs)		72	64	
24: HF5N5V8A	1.0 ^c	15 (0-50Yrs)	5 (50-100Yrs) & 2.5 (100-300Yrs)		71	62	
25: HF5N3VI8	1.45		3 (50-100Yrs), 1.5 (100-300Yrs), & 1.0 (300-10,000Yrs)		72	57	

Note: ^a Thermal conductivity values reduced by 25 percent.

^b Thermal conductivity values raised by 25 percent.

^c Initial linear heat load with additional 18 years of waste aging.

Table 6-8. Effect of Drift Spacing Change on Peak Drift Wall and Waste Package Surface Temperatures

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak Temperature (°C) / Time To Peak (Year)	
					Drift Wall	WP Surface
15: HF5N5V8	1.45	15	5 (50-100Yrs) & 2.5 (100-300Yrs)	81	94 / 728	96 / 668
17: LF5N5V8	1.0				73 / 768	75 / 648
18: HF5N5V4	1.45			40.5	136 / 970	138 / 950
20: LF5N5V4	1.0				107 / 1210	108 / 1170
21: HF5N5V2	1.45			25	187 / 1336	188 / 1336

Table 6-9. Effect of Variation of Thermal Conductivity Values on Peak Drift Wall and Waste Package Surface Temperatures

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak Temperature (°C) / Time To Peak (Year)	
					Drift Wall	WP Surface
15: HF5N5V8	1.45	15	5 (50-100Yrs) & 2.5 (100-300Yrs)	81	94 / 728	96 / 668
22: HF5N5V8KD ^a					107 / 717	109 / 668
23: HF5N5V8KU ^b					88 / 748	90 / 668

Note: ^a Thermal conductivity values reduced by 25 percent.

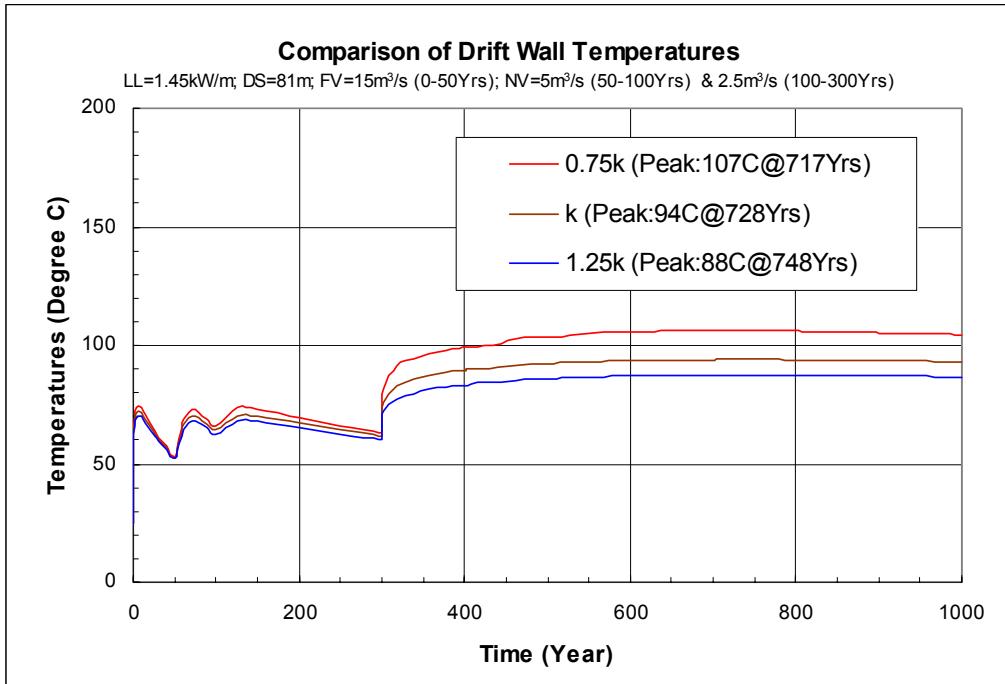
^b Thermal conductivity values raised by 25 percent.

Table 6-10. Effect of Variation of Waste Ages on Peak Drift Wall and Waste Package Surface Temperatures

Case ID	Initial Linear Heat Load (kW/m)	Air Flow Rate of Forced Ventilation (Duration) (m ³ /s)	Air Flow Rate of Natural Ventilation (Duration) (m ³ /s)	Drift Spacing (m)	Peak Temperature (°C) / Time To Peak (Year)	
					Drift Wall	WP Surface
15: HF5N5V8	1.45	15	5 (50-100Yrs) & 2.5 (100-300Yrs)	81	94 / 728	96 / 668
17: LF5N5V8	1.0 ^a				73 / 768	75 / 648
24: HF5N5V8A	1.0 ^b				92 / 710	94 / 690

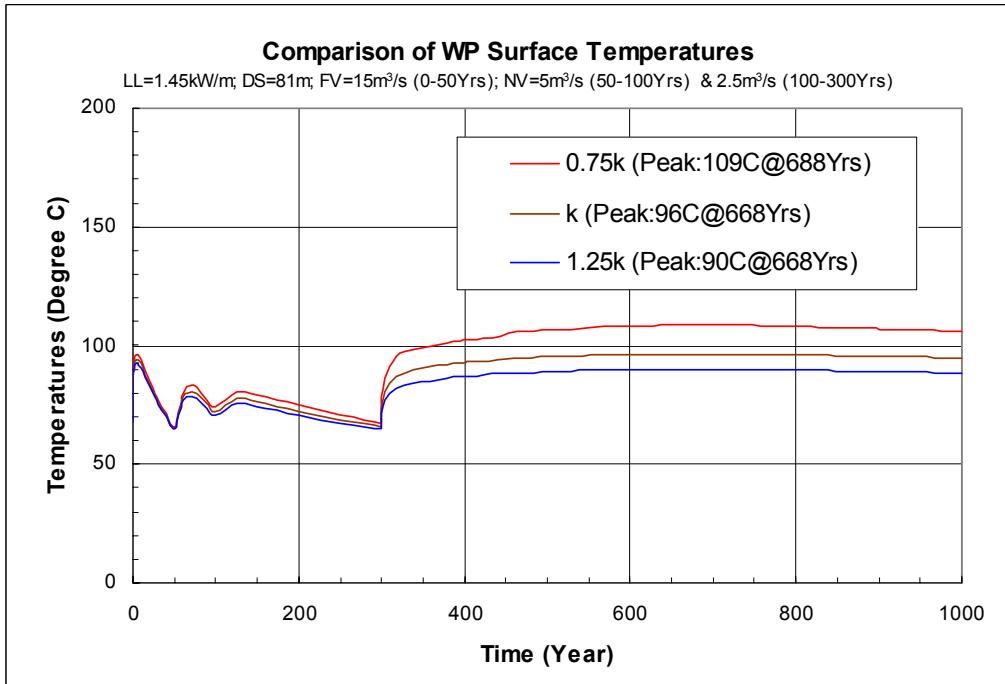
Note: ^a Initial linear heat load by spacing.

^b Initial linear heat load by aging.



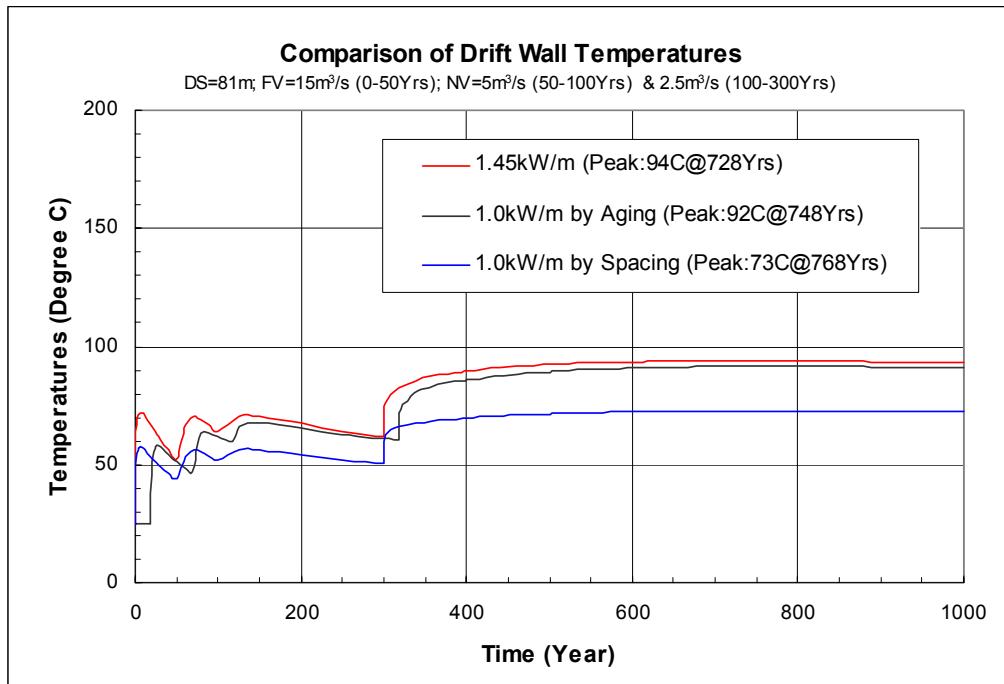
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure 6-1. Comparison of Drift Wall Temperatures for Cases with Different Thermal Conductivity Values for Stratigraphic Units



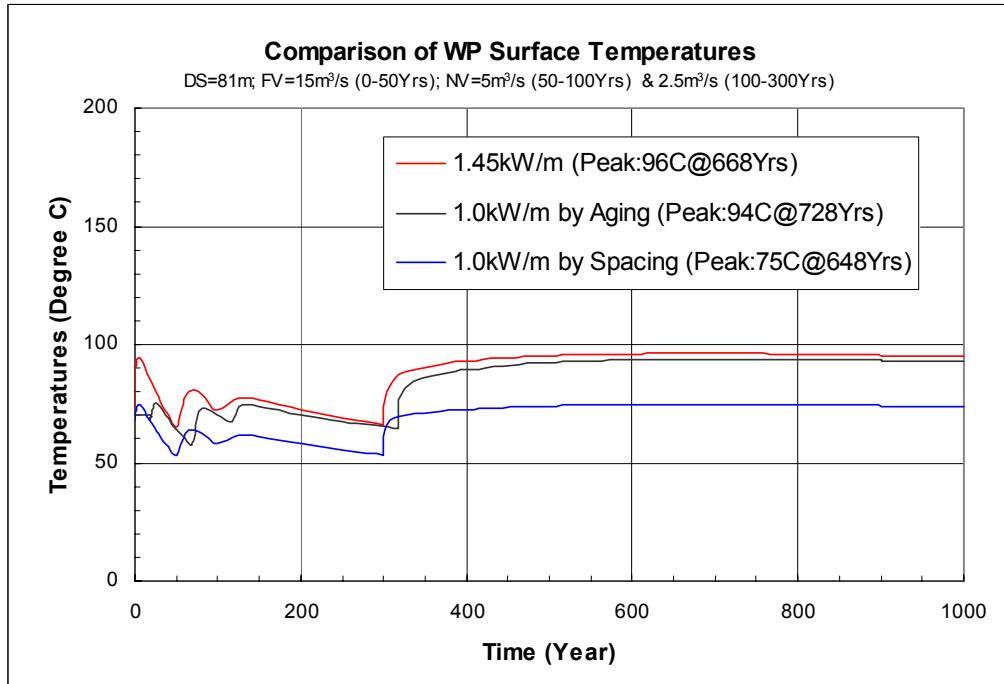
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure 6-2. Comparison of Waste Package Surface Temperatures for Cases with Different Thermal Conductivity Values for Stratigraphic Units



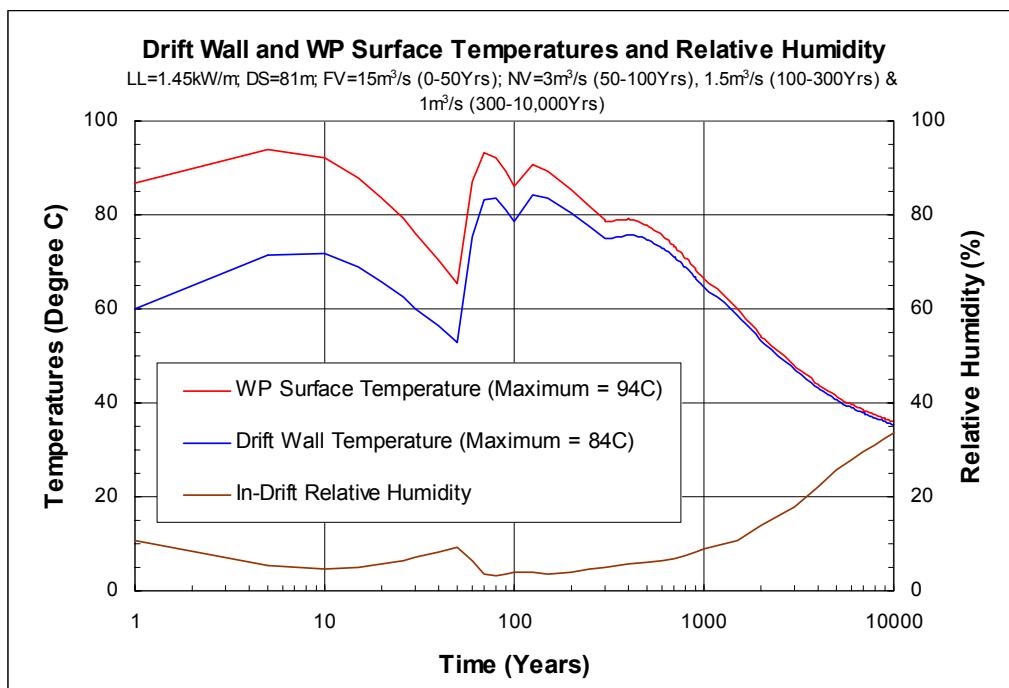
Note: DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure 6-3. Comparison of Drift Wall Temperatures for Cases with Different Waste Ages



Note: DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure 6-4. Comparison of Waste Package Surface Temperatures for Cases with Different Waste Ages



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure 6-5. Time Histories of Drift Wall and WP Surface Temperatures and In-drift Relative Humidity for Case:HF5N3VI8.

7. REFERENCES

7.1 DOCUMENTS CITED

ASTM B 575-97. 1998. *Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 241816.

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1997. *Software Qualification Report for ANSYS Revision 5.2SGI.* CSCI: 30013 V5.2SGI. DI: 30013-2003, Rev. 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19970815.0536.

CRWMS M&O 1998a. *Repository Ground Support Analysis for Viability Assessment.* BCAA00000-01717-0200-00004 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980512.0714.

CRWMS M&O 1998b. *Repository Subsurface Waste Emplacement and Thermal Management Strategy.* B00000000-01717-0200-00173 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980918.0084.

CRWMS M&O 1998c. *Multiple WP Emplacement Thermal Response - Suite 1.* BBA000000-01717-0210-00001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980807.0311.

CRWMS M&O 1999a. *ANSYS Thermal Calculations in Support of Waste Quantity, Mix and Throughput Study.* CAL-EBS-MG-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000119.0134.

CRWMS M&O 1999b. *Thermal Modeling Parameters by Stratigraphic Unit.* Input Transmittal SSR-NEP-99261.T. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990910.0090; MOL.19990920.0109.

CRWMS M&O 1999c. *Post Closure Open-Loop Natural Ventilation.* BCAD00000-01717-0210-00002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990806.0069.

CRWMS M&O 2000a. *Technical Work Plan for: Natural Ventilation Parametric Study.* TWP-SVS-SE-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000922.0012.

CRWMS M&O 2000b. *Enhanced Design Alternative (EDA) II Repository Estimated Waste Package Types and Quantities.* Input Transmittal 00147.T. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000324.0292.

CRWMS M&O 2000c. *Subsurface Ventilation System Description Document.* SDD-SVS-SE-000001 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000803.0356.

CRWMS M&O 2000d. *Subsurface Facility System Description Document*. SDD-SFS-SE-000001 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000807.0078.

Hartman, H.L.; Mutmansky, J.M.; Ramani, R.V.; and Wang, Y.J. 1997. *Mine Ventilation and Air Conditioning*. 3rd Edition. New York, New York: John Wiley & Sons. TIC: 236391.

Holman, J.P. 1997. *Heat Transfer*. 8th Edition. New York, New York: McGraw-Hill Publishing Company. TIC: 239954.

Incropera, F.P. and DeWitt, D.P. 1985. *Fundamentals of Heat and Mass Transfer*. New York, New York: John Wiley & Sons. TIC: 208420.

Lide, D.R., ed. 1995. *CRC Handbook of Chemistry and Physics*. 76th Edition. Boca Raton, Florida: CRC Press. TIC: 216194.

Perry, R.H. and Green, D., eds. 1984. *Perry's Chemical Engineers' Handbook*. 6th Edition. New York, New York: McGraw-Hill. TIC: 246473.

Sass, J.H.; Lachenbruch, A.H.; Dudley, W.W., Jr.; Priest, S.S.; and Munroe, R.J. 1988. *Temperature, Thermal Conductivity, and Heat Flow Near Yucca Mountain, Nevada: Some Tectonic and Hydrologic Implications*. Open-File Report 87-649. [Denver, Colorado]: U.S. Geological Survey. TIC: 203195.

Swanson Analysis Systems 1995. *ANSYS User's Manual for Revision 5.2*. Four volumes. Houston, Pennsylvania: Swanson Analysis Systems. TIC: 221933.

White, F.M. 1986. *Fluid Mechanics*. 2nd Edition. New York, New York: McGraw-Hill. TIC: 243415.

7.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

CRWMS M&O 2000e. *Software Code: ANSYS*. V5.2SGI. Unix. 30013 V5.2SGI.

AP-3.12Q, Rev. 0, ICN 4. *Calculations*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010404.0008.

AP-3.14Q, Rev 0, ICN 1. *Transmittal of Input*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000427.0419.

AP-3.15Q, Rev. 2, ICN 1. *Managing Technical Product Inputs*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010405.0011.

AP-SI.1Q, Rev. 3, ICN 1. *Software Management*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010515.0126.

AP-2.21Q, Rev. 1, ICN 0, BSCN 001. *Quality Determinations and Planning for Scientific, Engineering, and Regulatory Compliance Activities*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010212.0018.

7.3 SOURCE DATA

MO0003RIB00071.000. Physical and Chemical Characteristics of Alloy 22. Submittal date: 03/13/00.

SN0003T0571897.013. Thermal Modeling Parameters by Stratigraphic Unit. Submittal date: 03/29/2000.

SN0011T0571897.014. Revised Thermal Modeling Parameters for Conduction-Only Models by Stratigraphic Unit. Submittal date: 11/29/2000.

7.4 OUTPUT DATA

MO0010MWDANS03.005. Input and Output Files for ANSYS Calculations in Support of Natural Ventilation Parametric Study for SR. Submittal date: 10/30/2000.

MO0103MWDTEM00.007. Temperatures and Relative Humidity for Operating Mode 50-Year Forced Ventilation and Indefinite Natural Ventilation. Submittal date: 03/22/2001.

8. ATTACHMENTS

Attachment	Title
I	Calculation of Heat Decay Percentage Values and Volumetric heat generation Rates
II	Temperatures and Heat Removal Rates for Case 01: HF2N1C8
III	Temperatures and Heat Removal Rates for Case 02: HF2N2C8
IV	Temperatures and Heat Removal Rates for Case 03: HF2N3C8
V	Temperatures and Heat Removal Rates for Case 04: HF2N4C8
VI	Temperatures and Heat Removal Rates for Case 05: HF2N5C8
VII	Temperatures and Heat Removal Rates for Case 06: HF5N1C8
VIII	Temperatures and Heat Removal Rates for Case 07: HF5N2C8
IX	Temperatures and Heat Removal Rates for Case 08: HF5N3C8
X	Temperatures and Heat Removal Rates for Case 09: HF5N4C8
XI	Temperatures and Heat Removal Rates for Case 10: HF5N5C8
XII	Temperatures and Heat Removal Rates for Case 11: HF7N1C8
XIII	Temperatures and Heat Removal Rates for Case 12: HF7N3C8
XIV	Temperatures and Heat Removal Rates for Case 13: HF7N5C8
XV	Temperatures and Heat Removal Rates for Case 14: HF5N3V8
XVI	Temperatures and Heat Removal Rates for Case 15: HF5N5V8
XVII	Temperatures and Heat Removal Rates for Case 16: LF5N3V8
XVIII	Temperatures and Heat Removal Rates for Case 17: LF5N5V8
XIX	Temperatures and Heat Removal Rates for Case 18: HF5N5V4
XX	Temperatures and Heat Removal Rates for Case 19: LF5N3V4
XXI	Temperatures and Heat Removal Rates for Case 20: LF5N5V4
XXII	Temperatures and Heat Removal Rates for Case 21: HF5N5V2

- XXIII Temperatures and Heat Removal Rates for Case 22: HF5N5V8KD
- XXIV Temperatures and Heat Removal Rates for Case 23: HF5N5V8KU
- XXV Temperatures and Heat Removal Rates for Case 24: HF5N5V8
- XXVI Temperatures and Heat Removal Rates for Case 25: HF5N3VI8
- XXVII Calculation of In-drift Relative Humidity for Case 25: HF5N3VI8

ATTACHMENT I

**CALCULATION OF HEAT DECAY PERCENTAGE VALUES AND VOLUMETRIC
HEAT GENERATION RATES**

This attachment presents the calculations of the heat decay percentage values with respect to the total initial heat output value for all CSNF waste packages and the volumetric heat generation rates used in this calculation.

The heat decay values in the form of volumetric heat generation rates for all 21-PWR waste packages are calculated for the initial linear heat loads of 1.0 and 1.45 kW/m. The following parameter values are used in the calculation:

Length of 21-PWR waste package:	5.305 m (Section 5.1.5.4)
Diameter of 21-PWR waste package:	1.564 m (Section 5.1.5.4)
Number of 21-PWR waste packages (absorber plates):	4,279 (Table 5-3)
Number of 21-PWR waste package (control rods):	87 (Table 5-3)
Number of 12-PWR waste package (long):	158 (Table 5-3)
Number of 44-BWR waste package (absorber plates):	2,889 (Table 5-3)
Number of 44-BWR waste package (thick absorber plates):	6 (Table 5-3)
Conversion factor:	3.1536×10^7 seconds/year

The conversion factor is used to convert the units from watts (joules/second) to joules/year, and is determined by taking 365 days for a year, 24 hours for a day, and 3,600 seconds for an hour as follows:

$$365 \text{ day/year} \times 24 \text{ hours/day} \times 3600 \text{ seconds/hour} = 3.1536 \times 10^7 \text{ seconds/year}$$

I-1 Volumetric Heat Generation Rates for Waste without Additional Aging

I-1.1 Heat Decay Percentage Values

The volumetric heat generation rates of waste packages are calculated based on weighted average heat decay percentages. The weighted average heat decay percentage for a given year is determined by dividing the total heat generated by all of the CSNF waste packages at that time by their total heat generated at the time of emplacement. For example, at year 1, the total heat generated by all CSNF waste packages (see Tables 5-4 and 5-5) is:

$$10.9954 \times 4279 + 2.3285 \times 87 + 9.2722 \times 158 + 6.9146 \times 2889 + 0.4829 \times 6 = 68,696.0805 \text{ kW}$$

and the total heat generated by all CSNF waste packages at the time of emplacement (see Tables 5-4 and 5-5) is:

$$11.3337 \times 4279 + 2.3709 \times 87 + 9.5402 \times 158 + 7.1346 \times 2889 + 0.491 \times 6 = 70,825.3276 \text{ kW}$$

Thus, the average heat decay percentage with respect to the initial heat output at year 1 is:

$$\frac{\text{Total Heat at 1 Year}}{\text{Total Heat at 0 Year}} = \frac{68696.0805}{70825.3276} = 96.99 \text{ percent}$$

The average percentage values of the initial heat output at various time are given in Table I-1, Column 8.

Table I-1. Heat Generation Rates of Various Waste Packages

Time (year)	21-PWR Absorber Plates (kW/pk)	21-PWR Control Rods (kW/pk)	12-PWR Long (kW/pk)	44-BWR Absorber Plates (kW/pk)	24-BWR Absorber Plates (kW/pk)	Total Heat of All CSNF Waste Package (kW)	Decay Percentage with respect to Initial Total Heat
0.01	11.3337	2.3709	9.5402	7.1346	0.491	70825.33	100.00%
1	10.9954	2.3285	9.2722	6.9146	0.4829	68696.08	96.99%
5	9.9653	2.1785	8.4286	6.2682	0.4445	62274.26	87.93%
10	8.9956	2.0095	7.5901	5.6536	0.403	56201.90	79.35%
15	8.1887	1.8547	6.8815	5.1467	0.3689	51159.11	72.23%
20	7.5138	1.7241	6.3149	4.7102	0.3341	46909.07	66.23%
26	6.8050 ^a	1.5819 ^a	5.7089 ^a	4.2419 ^a	0.3013 ^a	42414.93	59.89%
30	6.3792	1.4942	5.3407	3.9701	0.2806	39741.73	56.11%
40	5.4984	1.3106	4.5868	3.3915	0.2369	34165.86	48.24%
50	4.7912	1.1649	3.9792	2.9326	0.2033	29705.11	41.94%
60	4.2229	1.0443	3.5026	2.5621	0.1754	26117.01	36.88%
70	3.7685	0.9479	3.1031	2.2625	0.1536	23235.45	32.81%
75	3.5654	0.9070	2.9482	2.1366	0.1445	21974.58	31.03%
80	3.3915	0.8698	2.7908	2.0227	0.1361	20873.24	29.47%
90	3.0866	0.807	2.5304	1.8264	0.1222	18954.78	26.76%
100	2.8314	0.7545	2.3024	1.6685	0.1111	17365.94	24.52%
125	2.4552	0.6764	1.9895	1.4331	0.0955	15019.79	21.21%
150	2.079	0.5983	1.6766	1.1977	0.0799	12673.63	17.89%
200	1.7291	0.5244	1.3818	0.9878	0.0684	10516.93	14.85%
250	1.5128	0.4796	1.2029	0.8725	0.0622	9226.08	13.03%
300	1.3654	0.4452	1.0804	0.7889	0.0583	8331.46	11.76%
400	1.1571	0.395	0.9118	0.6679	0.0528	7059.54	9.97%
500	1.0046	0.3492	0.7901	0.5821	0.0485	6135.88	8.66%
600	0.8839	0.3167	0.6928	0.5188	0.0449	5418.31	7.65%
700	0.7888	0.2873	0.618	0.4629	0.0415	4835.48	6.83%
800	0.7071	0.2629	0.5533	0.4202	0.0386	4350.16	6.14%
900	0.6367	0.2415	0.4962	0.3832	0.0367	3931.13	5.55%
1000	0.5804	0.2245	0.4538	0.3538	0.0346	3597.10	5.08%
1500	0.3969	0.1653	0.3077	0.2477	0.0283	2477.11	3.50%
2000	0.3093	0.1363	0.2395	0.1984	0.0247	1946.52	2.75%
3000	0.2402	0.1134	0.182	0.1593	0.0221	1526.79	2.16%
4000	0.2167	0.1042	0.1664	0.1421	0.0206	1373.27	1.94%
5000	0.1995	0.0977	0.1529	0.1307	0.0194	1264.03	1.78%
6000	0.1867	0.0916	0.1428	0.1214	0.0185	1180.26	1.67%
7000	0.1728	0.0869	0.1315	0.1131	0.018	1094.60	1.55%
8000	0.1619	0.0823	0.1236	0.106	0.017	1025.80	1.45%
9000	0.1523	0.0781	0.1162	0.099	0.0158	962.95	1.36%
10000	0.1432	0.0739	0.1088	0.0924	0.0154	903.41	1.28%

Note: ^a Values linearly interpolated for this calculation.

Columns 2 through 6 are from Table 5-5.

I-1.2 Volumetric Heat Generation Rates

The decay percentage values are used to determine the volumetric heat generation rates per waste package by multiplying the initial linear heat output value, such as 1.0 kW/m, by the decay percentage and then dividing by the volume of the 21-PWR waste package per linear meter. For example, at year 1 for an initial linear heat output of 1.0 kW/m, the volumetric heat generation rate is:

$$\frac{\text{Heat at 1 Year}}{\text{WP Volume}} = \frac{1.0 \times 0.9699}{\frac{1}{4} \times \pi \times 1.564^2} = 0.5049 \text{ kW/m}^3$$

To convert the units from joule/second to joule/year, the above volumetric heat generation rate is multiplied by the conversion factor of 3.1536×10^7 seconds/year. Table I-1 lists the total heat generation rates of all of the CSNF waste packages and the calculated decay percentage with respect to the initial total heat output value of all CSNF waste packages. Table I-2 gives the volumetric heat generation rates for the initial linear heat output values of 1.0 and 1.45 kW/m.

I-2 Volumetric Heat Generation Rates for Waste with Additional Aging

As stated in Section 5.3.3.3, a case with additional 18 years of waste aging is modeled. To analyze this case, the decay values of waste is set to be equal to those at 18 years older for other cases without additional waste aging, that is

$$P_{w/ \text{ aging}}(t) = P_{w/o \text{ aging}}(t+18) \quad (\text{Eq. I-1})$$

where $P_{w/ \text{ aging}}$ = heat power of waste with additional aging, kW/package
 $P_{w/o \text{ aging}}$ = heat power of waste without additional aging, kW/package
 t = time, year

For example, the volumetric heat generation rate at $t=2$ years for waste with additional 18 years of aging is equal to that at 20 years for waste without additional aging, or

$$P_{w/ \text{ aging}}(2) = P_{w/o \text{ aging}}(20) = 1.58 \times 10^{10} \text{ J / yr} \cdot \text{m}^3$$

Table I-3 gives the volumetric heat generation rates for waste with additional 18 years of aging.

Table I-2. Volumetric Heat Generation Rates for Linear Heat Loads of 1.0 and 1.45 kW/m

Time (year)	Decay Percentage with respect to Initial Total Heat	LL=1.0 kW/m (J/yr·m ³)	LL=1.45 kW/m (J/yr·m ³)
0.01	100.00%	1.64E+10	2.38E+10
1	96.99%	1.59E+10	2.31E+10
5	87.93%	1.44E+10	2.09E+10
10	79.35%	1.30E+10	1.89E+10
15	72.23%	1.19E+10	1.72E+10
20	66.23%	1.09E+10	1.58E+10
26	59.89%	9.83E+09	1.43E+10
30	56.11%	9.21E+09	1.34E+10
40	48.24%	7.92E+09	1.15E+10
50	41.94%	6.88E+09	9.98E+09
60	36.88%	6.05E+09	8.78E+09
70	32.81%	5.39E+09	7.81E+09
75	31.03%	5.60E+09	7.38E+09
80	29.47%	4.84E+09	7.01E+09
90	26.76%	4.39E+09	6.37E+09
100	24.52%	4.02E+09	5.84E+09
125	21.21%	3.48E+09	5.05E+09
150	17.89%	2.94E+09	4.26E+09
200	14.85%	2.44E+09	3.53E+09
250	13.03%	2.14E+09	3.10E+09
300	11.76%	1.93E+09	2.80E+09
400	9.97%	1.64E+09	2.37E+09
500	8.66%	1.42E+09	2.06E+09
600	7.65%	1.26E+09	1.82E+09
700	6.83%	1.12E+09	1.63E+09
800	6.14%	1.01E+09	1.46E+09
900	5.55%	9.11E+08	1.32E+09
1000	5.08%	8.34E+08	1.21E+09
1500	3.50%	5.74E+08	8.32E+08
2000	2.75%	4.51E+08	6.54E+08
3000	2.16%	3.54E+08	5.13E+08
4000	1.94%	3.18E+08	4.62E+08
5000	1.78%	2.93E+08	4.25E+08
6000	1.67%	2.74E+08	3.97E+08
7000	1.55%	2.54E+08	3.68E+08
8000	1.45%	2.38E+08	3.45E+08
9000	1.36%	2.23E+08	3.24E+08
10000	1.28%	2.09E+08	3.04E+08

Note: LL = Initial Linear Heat Load.

Table I-3. Volumetric Heat Generation Rates for Waste with Additional 18 Years of Aging

Time (year)	Decay Percentage with respect to Initial Total Heat	LL=1.0 kW/m by Aging (J/yr·m ³)
0.01	68.63%	1.63E+10
2	66.23%	1.58E+10
7	60.83%	1.45E+10
12	56.11%	1.34E+10
17	51.98%	1.24E+10
22	48.24%	1.15E+10
27	44.88%	1.07E+10
32	41.94%	9.98E+09
42	36.88%	8.78E+09
50	34.32%	8.17E+09
57	31.03%	7.38E+09
62	29.47%	7.01E+09
72	26.76%	6.37E+09
82	24.52%	5.84E+09
100	22.50%	5.35E+09
107	21.21%	5.05E+09
132	17.89%	4.26E+09
182	14.85%	3.53E+09
232	13.03%	3.10E+09
300	11.44%	2.72E+09
382	9.97%	2.37E+09
482	8.66%	2.06E+09
582	7.65%	1.82E+09
682	6.83%	1.63E+09
782	6.14%	1.46E+09
882	5.55%	1.32E+09
982	5.08%	1.21E+09

ATTACHMENT II

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 01: HF2N1C8

ATTACHMENT II

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 01: HF2N1C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removal rates) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 26 years and a natural ventilation air flow rate of 1 m³/s from 26 to 500 years (Case 01: HF2N1C8). Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table II-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 1 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	80.23	89.70	96.78	100.84	108.14	111.13
40.00	93.81	110.59	123.87	133.62	140.93	146.95
50.00	89.17	107.31	123.61	135.99	145.40	153.47
60.00	84.36	100.37	117.21	130.74	141.81	150.84
70.00	80.06	95.74	110.30	123.80	134.95	144.62
80.00	76.28	91.39	104.47	117.08	128.07	137.64
90.00	73.09	87.63	99.07	111.21	121.73	131.19
100.00	70.35	84.38	95.63	105.86	116.23	124.98
125.00	66.08	79.53	90.55	99.39	108.81	117.34
150.00	61.67	74.35	84.95	93.69	100.55	109.04
200.00	57.03	68.78	78.86	87.39	94.56	100.30
250.00	54.12	65.04	74.58	82.82	89.88	95.83
300.00	52.02	62.34	71.44	79.41	86.33	92.28
400.00	48.92	58.58	67.26	74.99	81.81	87.78
500.00	46.56	55.52	63.72	71.12	77.77	83.69

Source: DTN: MO0010MWDANS03.005

Table II-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 1 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	42.85	55.71	65.30	72.45	78.98	84.20
40.00	55.09	77.27	93.85	105.95	115.79	123.14
50.00	56.86	81.99	102.27	118.25	130.68	140.60
60.00	54.56	78.28	98.62	115.50	129.27	140.61
70.00	52.37	74.35	93.36	109.78	123.71	135.50
80.00	50.42	71.16	88.65	104.04	117.40	129.00
90.00	48.75	68.32	84.49	98.85	111.51	122.69
100.00	47.32	65.89	81.09	94.40	106.35	116.96
125.00	45.64	63.05	77.54	89.71	100.81	110.74
150.00	43.55	59.53	73.10	84.45	94.30	103.51
200.00	41.38	55.80	68.32	79.03	88.03	96.14
250.00	39.57	52.62	64.15	74.22	82.92	90.29
300.00	38.37	50.44	61.23	70.77	79.12	86.36
400.00	37.12	48.24	58.32	67.35	75.38	82.45
500.00	35.81	45.92	55.24	63.74	71.42	78.29

Source: DTN: MO0010MWDANS03.005

Table II-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 1 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	97.78	106.31	112.72	116.49	123.12	125.88
40.00	107.25	122.92	135.27	144.46	151.35	157.03
50.00	101.20	118.31	133.55	145.29	154.27	161.95
60.00	95.30	110.42	126.34	139.20	149.78	158.44
70.00	90.10	104.95	118.81	131.67	142.36	151.65
80.00	85.53	99.90	112.49	124.46	135.02	144.23
90.00	81.69	95.57	106.55	118.21	128.31	137.42
100.00	78.38	91.81	102.65	112.54	122.50	130.94
125.00	73.24	86.18	96.83	105.40	114.56	122.78
150.00	67.89	80.14	90.44	98.95	105.66	113.89
200.00	62.35	73.76	83.58	91.92	98.93	104.57
250.00	58.88	69.51	78.83	86.89	93.81	99.66
300.00	56.38	66.44	75.34	83.15	89.95	95.80
400.00	52.68	62.14	70.65	78.24	84.95	90.83
500.00	49.88	58.66	66.71	74.00	80.55	86.40

Source: DTN: MO0010MWDANS03.005

Table II-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-26 Years), and 1 m³/s (26-500 Years) (Drift Spacing = 81 m)

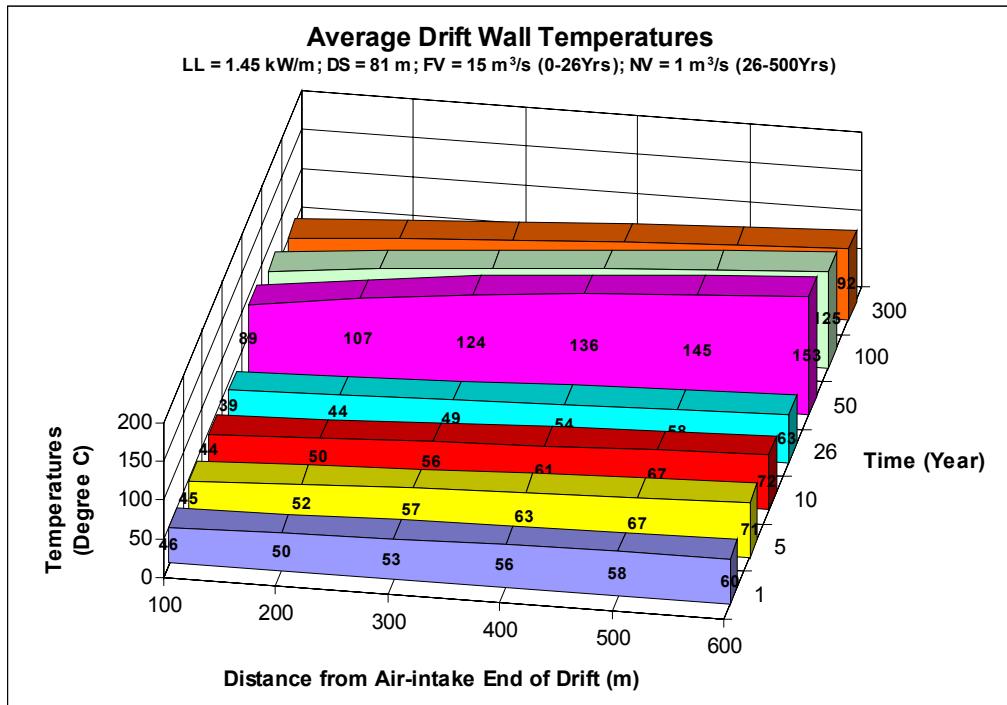
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	14.60	10.51	7.85	5.85	5.35	4.27
40.00	24.61	18.15	13.57	9.89	8.05	6.02
50.00	26.06	20.56	16.59	13.07	10.17	8.11
60.00	24.18	19.41	16.63	13.80	11.27	9.27
70.00	22.39	17.98	15.55	13.43	11.39	9.64
80.00	20.80	16.96	14.31	12.59	10.93	9.49
90.00	19.43	16.01	13.22	11.75	10.36	9.15
100.00	18.26	15.19	12.44	10.89	9.78	8.68
125.00	16.88	14.24	11.85	9.96	9.08	8.13
150.00	15.18	13.07	11.10	9.28	8.06	7.53
200.00	13.40	11.80	10.24	8.76	7.36	6.64
250.00	11.92	10.67	9.44	8.24	7.11	6.03
300.00	10.93	9.88	8.83	7.80	6.83	5.92

Source: DTN: MO0010MWDANS03.005

Table II-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-26 Years), and 1 m³/s (26-500 Years) (Drift Spacing = 81 m)

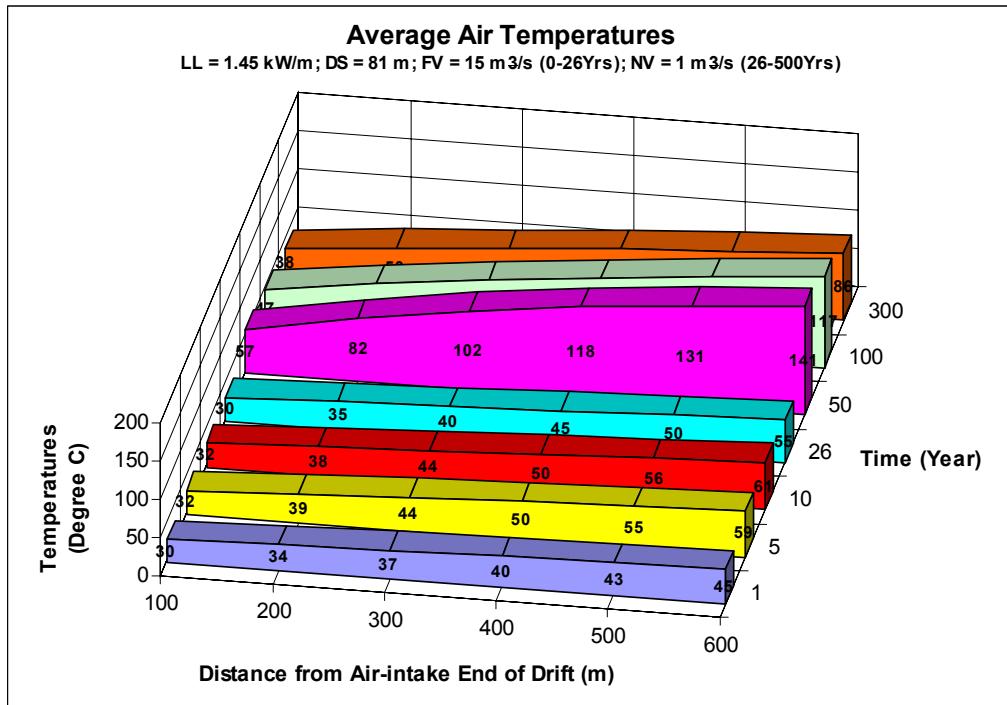
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	48.43	229.64	28967.96				
40.00	48.24%	419.68	453.93	143151.62	40.00	80.28	64.35	20294.41				
50.00	41.94%	364.89	392.29	123711.69	50.00	94.56	87.42	27569.26				
60.00	36.88%	320.81	342.85	108121.88	60.00	94.57	94.57	29822.42				
70.00	32.81%	285.42	303.12	95590.81	70.00	90.39	92.48	29163.69				
80.00	29.47%	256.40	270.91	85434.15	80.00	85.07	87.73	27666.49				
90.00	26.76%	232.84	244.62	77142.91	90.00	79.91	82.49	26015.34				
100.00	24.52%	213.32	223.08	70349.62	100.00	75.23	77.57	24462.60				
125.00	21.21%	184.50	198.91	156819.84	125.00	70.14	72.68	57303.07				
150.00	17.89%	155.68	170.09	134098.48	150.00	64.22	67.18	52964.43				
200.00	14.85%	129.19	142.43	224589.03	200.00	58.19	61.21	96511.21				
250.00	13.03%	113.33	121.26	191201.22	250.00	53.41	55.80	87988.29				
300.00	11.76%	102.34	107.84	170036.07	300.00	50.19	51.80	81681.23				
Total heat generated in 26 years (GJ)				545987.77	Total heat removed in 26 years (GJ)		361959.13					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		575921.29					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		952369.53					
Percentage of total heat removal in 26 years = 66%												
Percentage of total heat removal in 100 years = 44%												
Percentage of total heat removal in 300 years = 43%												

Source: DTN: MO0010MWDANS03.005



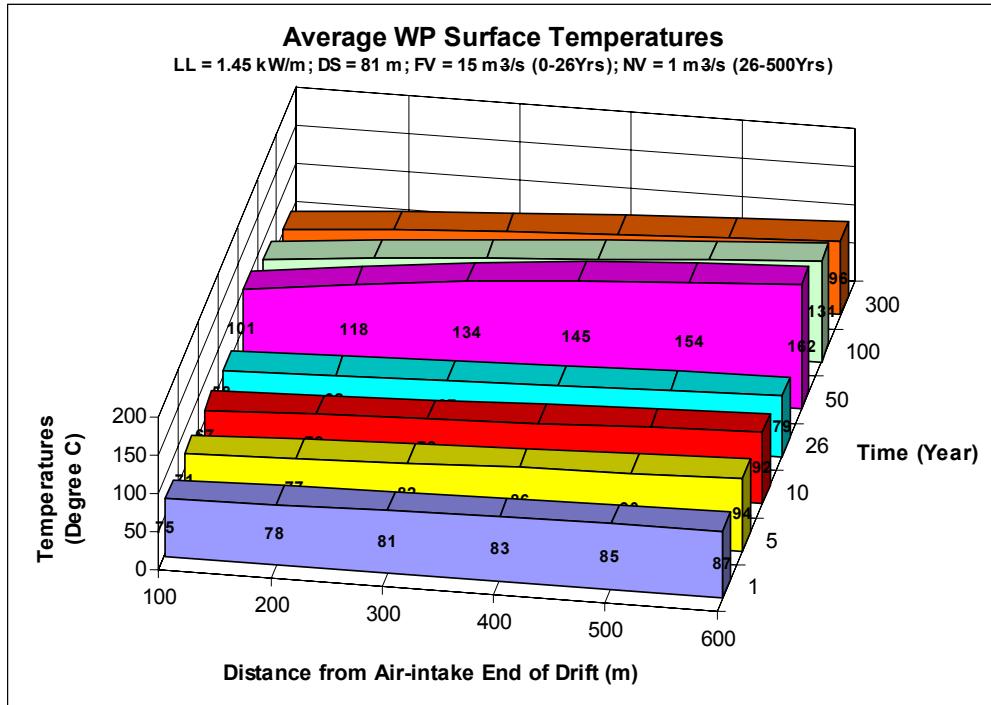
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table II-1, p. II-2.

Figure II-1. Average Drift Wall Temperatures for Case 01: HF2N1C8



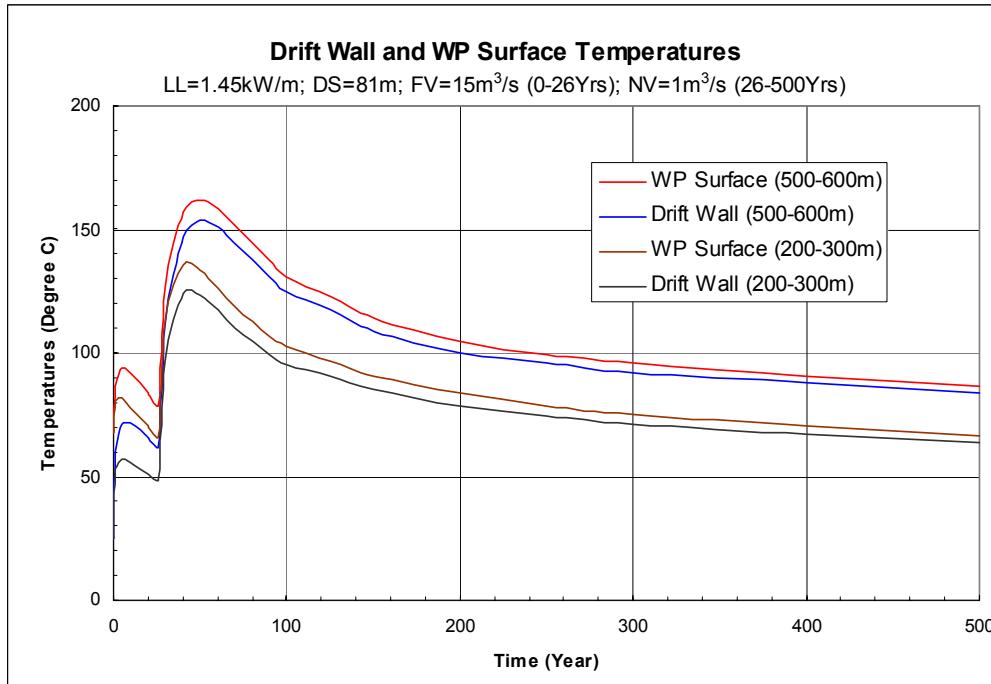
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table II-2, p. II-3.

Figure II-2. Average Air Temperatures for Case 01: HF2N1C8



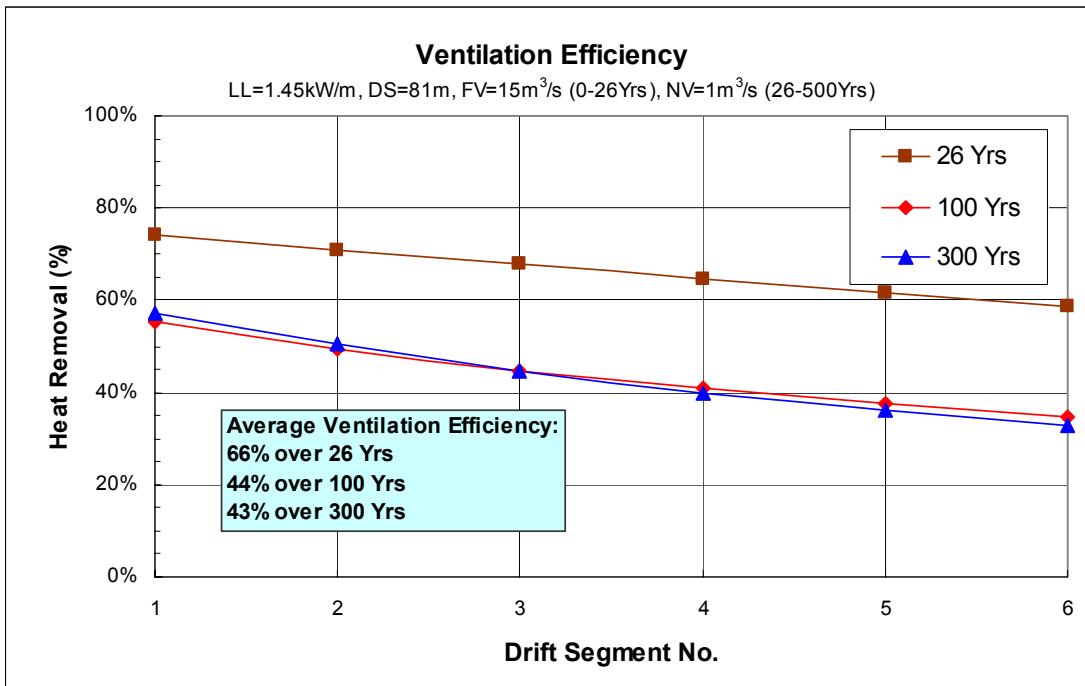
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table II-3, p. II-4.

Figure II-3. Average Waste Package Surface Temperatures for Case 01: HF2N1C8



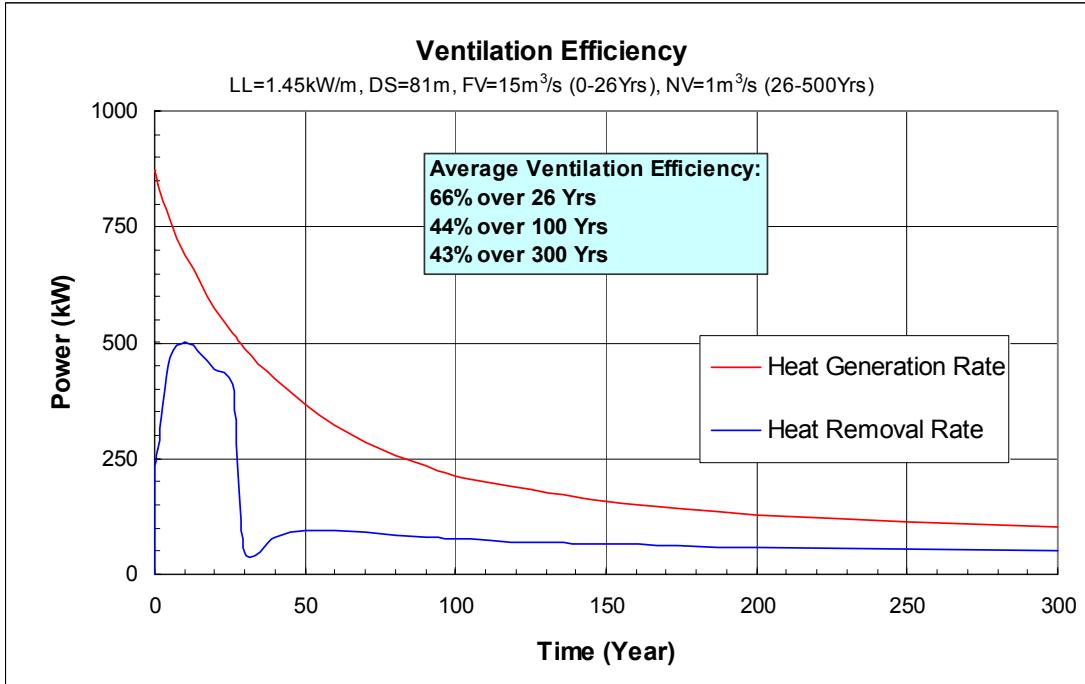
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure II-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 01: HF2N1C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure II-5. Average Heat Removal Rates at Different Drift Segments for Case 01: HF2N1C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure II-6. Overall Heat Generation and Removal Rates at Different Time for Case 01: HF2N1C8

ATTACHMENT III

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 02: HF2N2C8

ATTACHMENT III

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 02: HF2N2C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 26 years and a natural ventilation air flow rate of 2 m³/s from 26 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table III-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 2 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	69.82	78.31	85.28	91.14	96.21	99.53
40.00	74.84	87.55	97.81	107.67	115.94	122.78
50.00	70.46	83.88	95.33	106.13	116.06	124.52
60.00	66.42	79.19	90.43	99.93	110.24	119.43
70.00	62.95	74.97	85.67	95.00	104.04	112.76
80.00	59.96	71.27	81.43	90.40	98.20	106.06
90.00	57.47	68.16	77.82	86.42	94.01	100.47
100.00	55.36	65.50	74.72	82.97	90.33	96.81
125.00	52.08	61.57	70.29	78.17	85.28	91.65
150.00	48.77	57.46	65.54	72.96	79.74	85.90
200.00	45.37	53.16	60.51	67.37	73.74	79.63
250.00	43.27	50.29	57.00	63.32	69.27	74.83
300.00	41.78	48.27	54.48	60.39	65.97	71.23
400.00	39.61	45.52	51.23	56.72	61.96	66.94
500.00	38.00	43.33	48.53	53.59	58.46	63.15

Source: DTN: MO0010MWDANS03.005

Table III-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 2 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	38.37	49.02	57.70	64.98	71.24	76.54
40.00	45.23	61.55	74.76	85.79	95.04	102.61
50.00	45.14	62.38	77.03	89.91	101.24	111.06
60.00	43.35	59.53	73.73	86.28	97.81	108.22
70.00	41.76	56.71	70.03	81.76	92.63	102.70
80.00	40.39	54.24	66.68	77.78	87.79	97.08
90.00	39.23	52.12	63.79	74.28	83.63	92.09
100.00	38.25	50.34	61.33	71.27	80.21	88.15
125.00	37.11	48.28	58.53	67.89	76.39	84.04
150.00	35.72	45.76	55.12	63.77	71.73	79.01
200.00	34.30	43.15	51.52	59.39	66.73	73.54
250.00	33.13	40.96	48.45	55.57	62.29	68.61
300.00	32.38	39.49	46.33	52.86	59.08	64.97
400.00	31.60	38.03	44.26	50.27	56.03	61.52
500.00	30.80	36.52	42.13	47.59	52.88	57.98

Source: DTN: MO0010MWDANS03.005

Table III-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 2 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	87.86	95.50	101.80	107.12	111.72	114.83
40.00	89.50	101.25	110.80	120.07	127.73	134.08
50.00	83.59	96.07	106.81	117.03	126.31	134.29
60.00	78.33	90.27	100.85	109.86	119.59	128.32
70.00	73.82	85.12	95.24	104.11	112.79	121.04
80.00	69.93	80.62	90.27	98.82	106.30	113.88
90.00	66.71	76.84	86.04	94.27	101.56	107.80
100.00	63.96	73.61	82.42	90.33	97.41	103.67
125.00	59.70	68.78	77.15	84.75	91.62	97.79
150.00	55.35	63.71	71.51	78.69	85.27	91.27
200.00	50.96	58.49	65.62	72.29	78.50	84.24
250.00	48.25	55.06	61.58	67.74	73.55	78.98
300.00	46.32	52.64	58.68	64.44	69.90	75.06
400.00	43.51	49.28	54.86	60.23	65.37	70.26
500.00	41.42	46.63	51.73	56.69	61.48	66.08

Source: DTN: MO0010MWDANS03.005

Table III-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-26 Years), and 2 m³/s (26-500 Years) (Drift Spacing = 81 m)

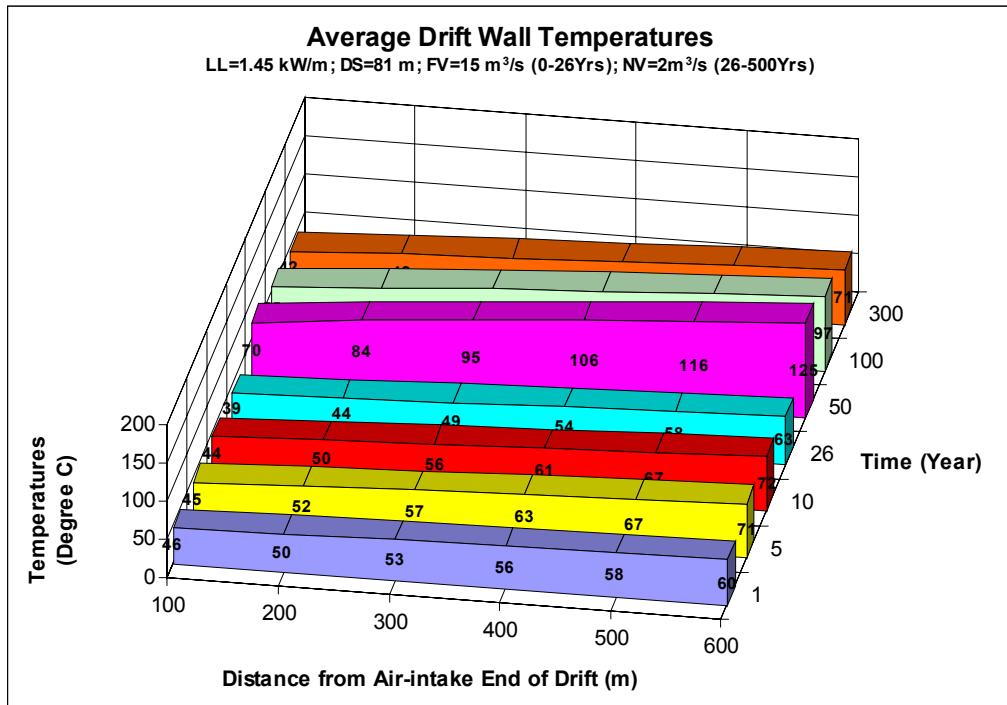
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	22.77	18.12	14.79	12.39	10.66	9.02
40.00	34.44	27.80	22.48	18.78	15.75	12.88
50.00	34.29	29.36	24.94	21.93	19.28	16.72
60.00	31.24	27.55	24.18	21.36	19.63	17.73
70.00	28.53	25.46	22.68	19.97	18.51	17.14
80.00	26.20	23.58	21.19	18.90	17.03	15.82
90.00	24.22	21.95	19.87	17.86	15.93	14.40
100.00	22.57	20.57	18.72	16.93	15.22	13.52
125.00	20.62	19.00	17.46	15.94	14.46	13.03
150.00	18.25	17.09	15.94	14.74	13.55	12.38
200.00	15.83	15.07	14.26	13.40	12.50	11.58
250.00	13.85	13.32	12.75	12.12	11.45	10.75
300.00	12.56	12.11	11.64	11.13	10.59	10.03

Source: DTN: MO0010MWDANS03.005

Table III-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-26 Years), and 2 m³/s (26-500 Years) (Drift Spacing = 81 m)

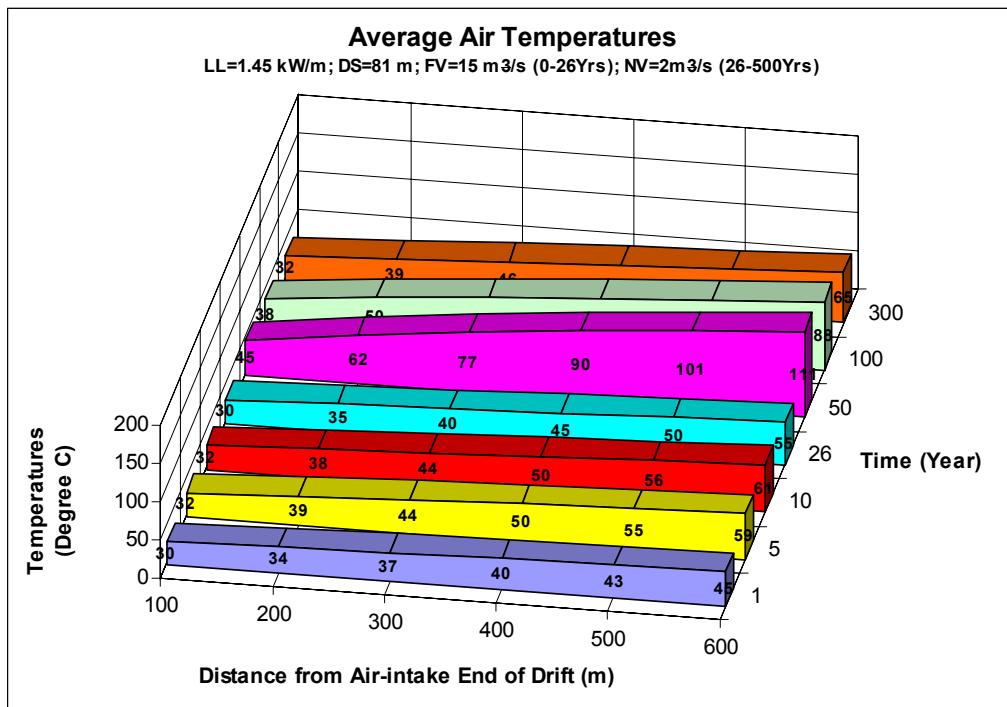
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07			
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31			
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37			
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24			
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48			
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32			
30.00	56.11%	488.18	504.60	63651.70	30.00	87.76	249.31	31448.69			
40.00	48.24%	419.68	453.93	143151.62	40.00	132.13	109.95	34672.39			
50.00	41.94%	364.89	392.29	123711.69	50.00	146.53	139.33	43938.81			
60.00	36.88%	320.81	342.85	108121.88	60.00	141.69	144.11	45446.44			
70.00	32.81%	285.42	303.12	95590.81	70.00	132.29	136.99	43202.10			
80.00	29.47%	256.40	270.91	85434.15	80.00	122.72	127.51	40210.64			
90.00	26.76%	232.84	244.62	77142.91	90.00	114.23	118.48	37362.36			
100.00	24.52%	213.32	223.08	70349.62	100.00	107.52	110.87	34965.22			
125.00	21.21%	184.50	198.91	156819.84	125.00	100.52	104.02	82010.69			
150.00	17.89%	155.68	170.09	134098.48	150.00	91.95	96.24	75872.91			
200.00	14.85%	129.19	142.43	224589.03	200.00	82.64	87.29	137643.21			
250.00	13.03%	113.33	121.26	191201.22	250.00	74.25	78.44	123686.36			
300.00	11.76%	102.34	107.84	170036.07	300.00	68.05	71.15	112190.09			
Total heat generated in 26 years (GJ)				545987.77	Total heat removed in 26 years (GJ)			361959.13			
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)			673205.79			
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)			1204609.04			
Percentage of total heat removal in 26 years = 66%											
Percentage of total heat removal in 100 years = 51%											
Percentage of total heat removal in 300 years = 55%											

Source: DTN: MO0010MWDANS03.005



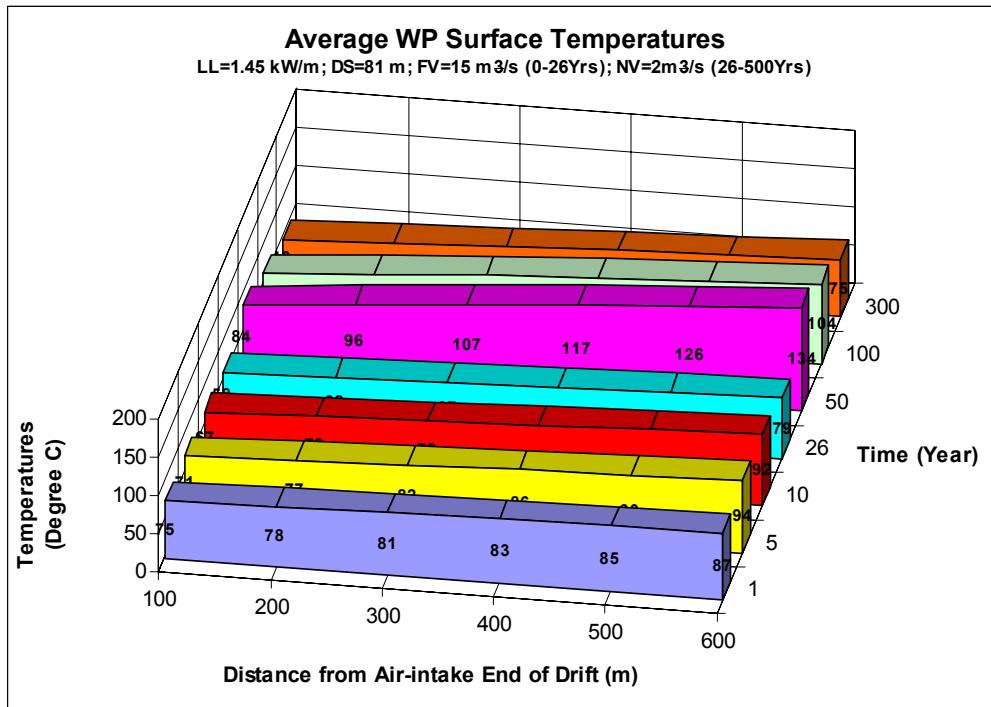
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table III-1, p. III-2.

Figure III-1. Average Drift Wall Temperatures for Case 02: HF2N2C8



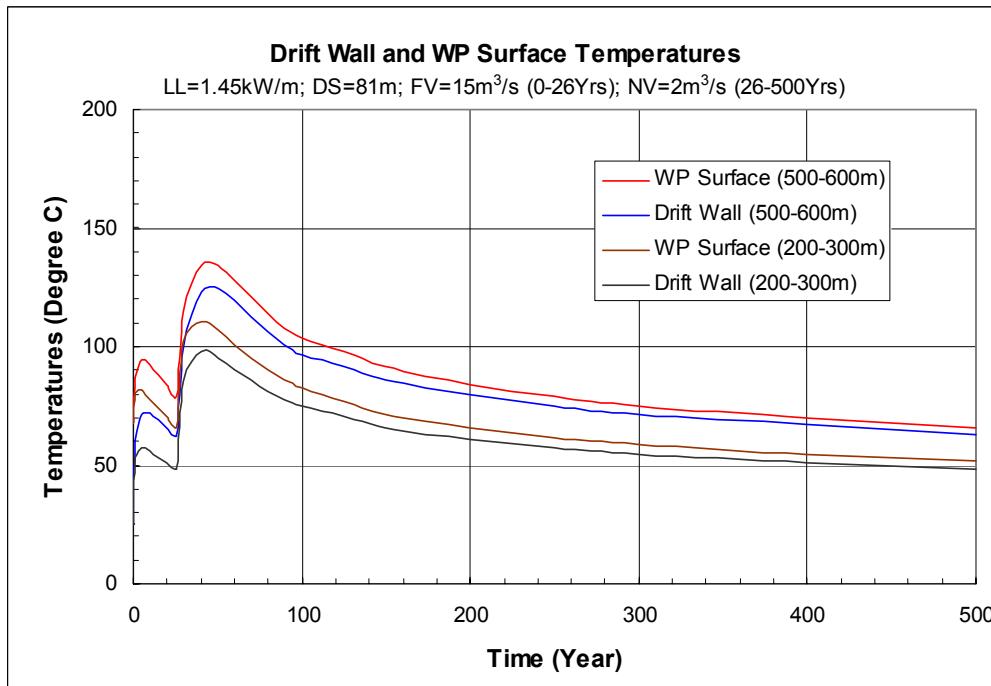
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table III-2, p. III-3.

Figure III-2. Average Air Temperatures for Case 02: HF2N2C8



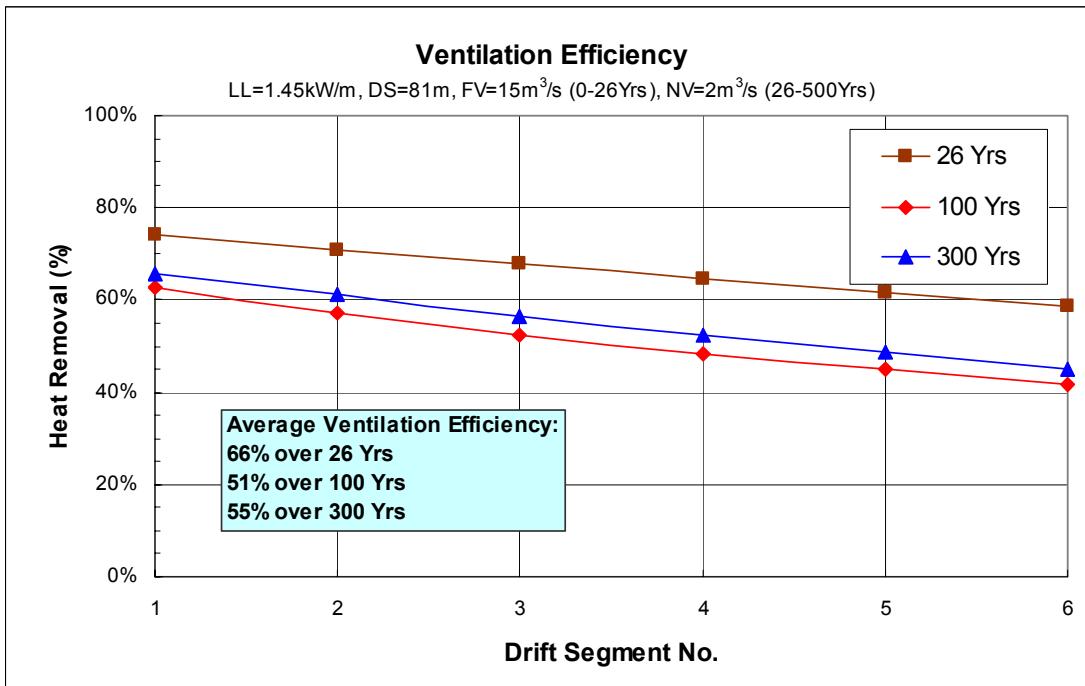
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table III-3, p. III-4.

Figure III-3. Average Waste Package Surface Temperatures for Case 02: HF2N2C8



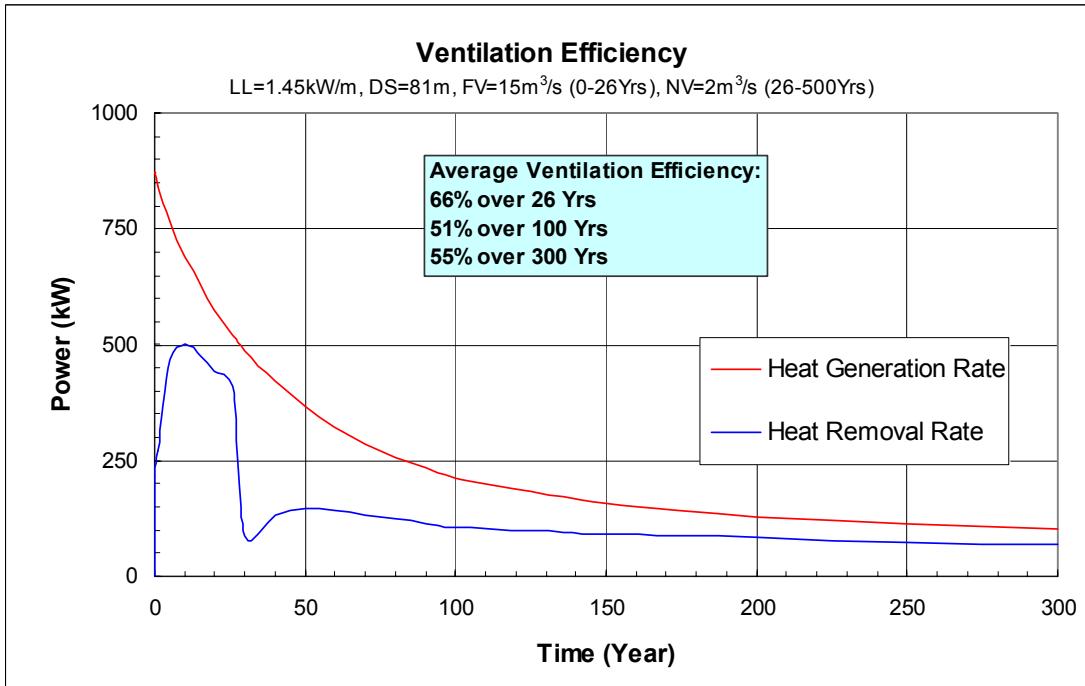
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure III-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 02: HF2N2C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure III-5. Average Heat Removal Rates at Different Drift Segments for Case 02: HF2N2C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure III-6. Overall Heat Generation and Removal Rates at Different Time for Case 02: HF2N2C8

ATTACHMENT IV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 03: HF2N3C8

ATTACHMENT IV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 03: HF2N3C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 26 years and a natural ventilation air flow rate of 3 m³/s from 26 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table IV-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 3 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	63.22	70.95	77.59	83.36	88.50	93.18
40.00	64.87	75.83	85.18	93.20	100.05	107.22
50.00	60.95	72.01	81.92	90.76	98.60	106.38
60.00	57.50	67.83	77.29	85.92	93.81	100.61
70.00	54.58	64.18	73.04	81.22	88.79	95.60
80.00	52.10	61.03	69.34	77.05	84.25	90.81
90.00	50.05	58.41	66.22	73.51	80.34	86.62
100.00	48.32	56.18	63.57	70.49	76.99	83.00
125.00	45.64	52.92	59.81	66.32	72.47	78.20
150.00	42.97	49.53	55.82	61.83	67.56	72.97
200.00	40.26	46.05	51.66	57.10	62.34	67.35
250.00	38.61	43.76	48.79	53.69	58.47	63.08
300.00	37.44	42.15	46.76	51.26	55.66	59.93
400.00	35.76	39.99	44.18	48.29	52.32	56.27
500.00	34.52	38.29	42.04	45.77	49.45	53.08

Source: DTN: MO0010MWDANS03.005

Table IV-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 3 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	36.02	45.26	53.16	60.05	66.17	71.70
40.00	40.49	53.68	64.94	74.58	82.85	90.25
50.00	39.89	53.31	65.30	75.95	85.37	94.05
60.00	38.44	50.82	62.18	72.54	81.96	90.58
70.00	37.19	48.52	59.02	68.72	77.67	85.82
80.00	36.13	46.53	56.24	65.28	73.69	81.45
90.00	35.24	44.86	53.88	62.32	70.22	77.56
100.00	34.49	43.45	51.89	59.81	67.26	74.22
125.00	33.63	41.84	49.64	57.02	64.00	70.57
150.00	32.57	39.89	46.92	53.65	60.07	66.18
200.00	31.51	37.88	44.09	50.10	55.91	61.49
250.00	30.66	36.23	41.70	47.05	52.27	57.32
300.00	30.10	35.13	40.07	44.92	49.66	54.29
400.00	29.54	34.05	38.51	42.90	47.23	51.46
500.00	28.97	32.94	36.90	40.84	44.75	48.61

Source: DTN: MO0010MWDANS03.005

Table IV-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 3 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	81.52	88.47	94.45	99.69	104.35	108.62
40.00	80.16	90.23	98.88	106.33	112.71	119.47
50.00	74.61	84.85	94.09	102.35	109.73	117.13
60.00	69.85	79.47	88.33	96.45	103.91	110.37
70.00	65.82	74.81	83.15	90.89	98.07	104.56
80.00	62.38	70.79	78.64	85.97	92.82	99.09
90.00	59.55	67.45	74.87	81.81	88.33	94.35
100.00	57.14	64.61	71.64	78.25	84.47	90.25
125.00	53.44	60.38	66.98	73.23	79.15	84.68
150.00	49.67	55.97	62.03	67.82	73.37	78.61
200.00	45.93	51.51	56.95	62.22	67.31	72.19
250.00	43.65	48.64	53.52	58.28	62.93	67.43
300.00	42.04	46.60	51.08	55.47	59.76	63.93
400.00	39.69	43.82	47.90	51.92	55.87	59.73
500.00	37.97	41.65	45.32	48.96	52.57	56.13

Source: DTN: MO0010MWDANS03.005

Table IV-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-26 Years), and 3 m³/s (26-500 Years) (Drift Spacing = 81 m)

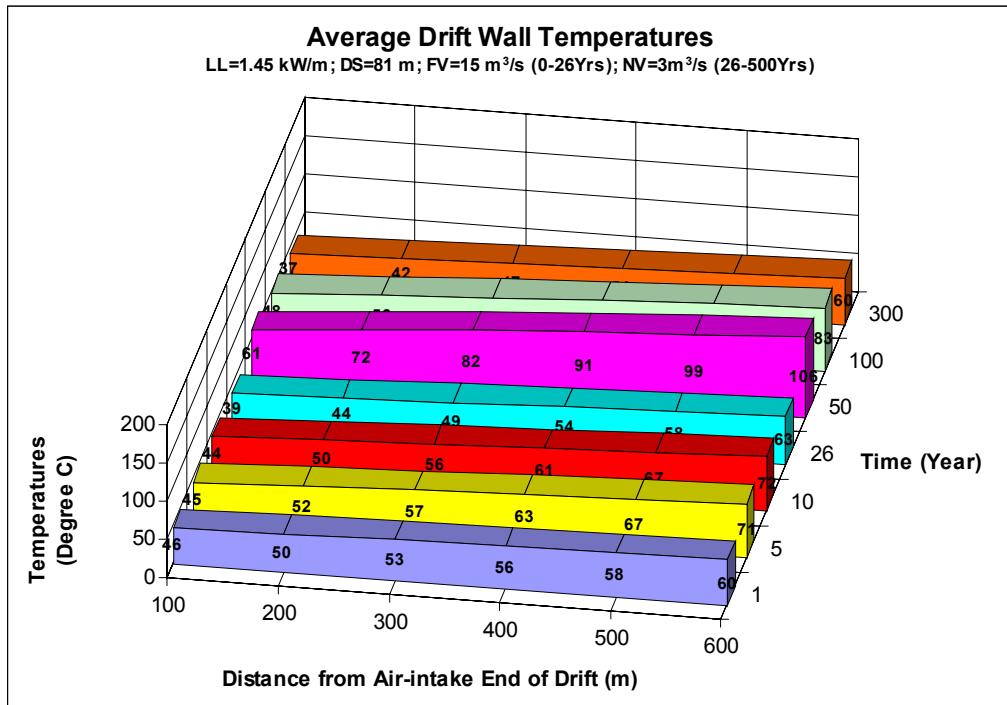
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	28.75	24.12	20.63	17.98	15.96	14.43
40.00	40.41	34.44	29.38	25.14	21.60	19.29
50.00	38.85	35.01	31.29	27.80	24.58	22.66
60.00	35.06	32.31	29.63	27.04	24.59	22.50
70.00	31.80	29.56	27.40	25.32	23.37	21.27
80.00	29.04	27.15	25.33	23.58	21.94	20.25
90.00	26.71	25.11	23.54	22.03	20.61	19.16
100.00	24.77	23.38	22.01	20.69	19.43	18.15
125.00	22.51	21.44	20.35	19.26	18.21	17.12
150.00	19.76	19.08	18.34	17.56	16.78	15.93
200.00	17.00	16.63	16.19	15.69	15.16	14.56
250.00	14.76	14.54	14.27	13.96	13.61	13.20
300.00	13.32	13.12	12.89	12.64	12.38	12.07

Source: DTN: MO0010MWDANS03.005

Table IV-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-26 Years), and 3 m³/s (26-500 Years) (Drift Spacing = 81 m)

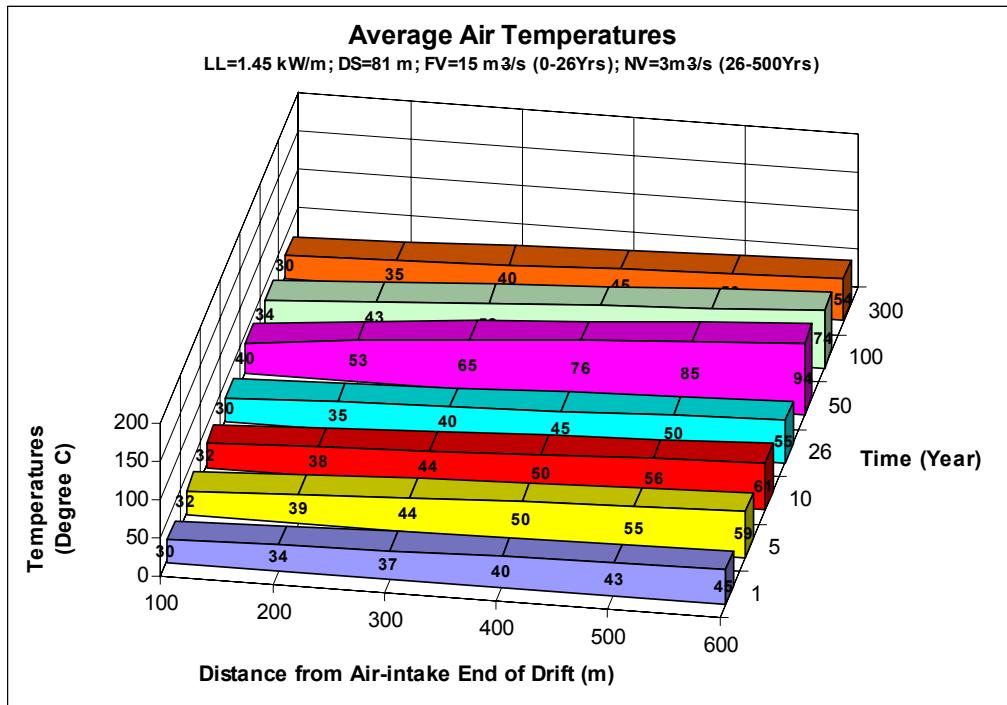
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	121.85	266.36	33599.17				
40.00	48.24%	419.68	453.93	143151.62	40.00	170.25	146.05	46058.94				
50.00	41.94%	364.89	392.29	123711.69	50.00	180.19	175.22	55256.88				
60.00	36.88%	320.81	342.85	108121.88	60.00	171.13	175.66	55394.95				
70.00	32.81%	285.42	303.12	95590.81	70.00	158.71	164.92	52008.58				
80.00	29.47%	256.40	270.91	85434.15	80.00	147.29	153.00	48250.79				
90.00	26.76%	232.84	244.62	77142.91	90.00	137.15	142.22	44850.83				
100.00	24.52%	213.32	223.08	70349.62	100.00	128.43	132.79	41876.60				
125.00	21.21%	184.50	198.91	156819.84	125.00	118.90	123.66	97497.11				
150.00	17.89%	155.68	170.09	134098.48	150.00	107.45	113.17	89226.33				
200.00	14.85%	129.19	142.43	224589.03	200.00	95.22	101.34	159785.54				
250.00	13.03%	113.33	121.26	191201.22	250.00	84.35	89.78	141569.72				
300.00	11.76%	102.34	107.84	170036.07	300.00	76.42	80.38	126745.54				
Total heat generated in 26 years (GJ)				545987.77	Total heat removed in 26 years (GJ)		361959.13					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		739255.87					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1354080.11					
Percentage of total heat removal in 26 years = 66%												
Percentage of total heat removal in 100 years = 56%												
Percentage of total heat removal in 300 years = 62%												

Source: DTN: MO0010MWDANS03.005



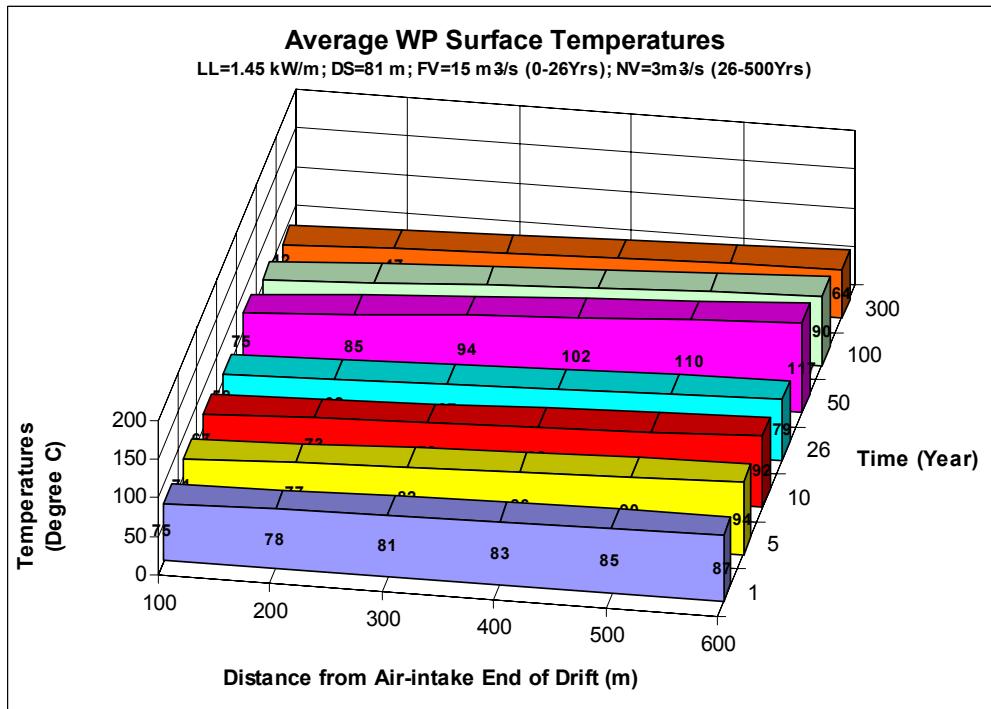
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table IV-1, p. IV-2.

Figure IV-1. Average Drift Wall Temperatures for Case 03: HF2N3C8



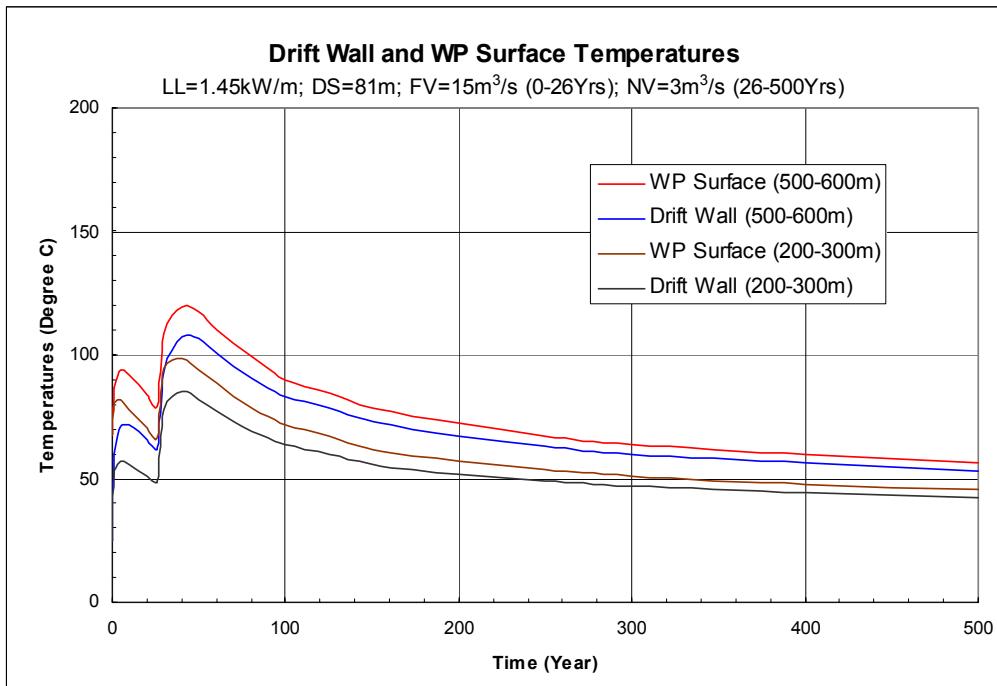
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table IV-2, p. IV-3.

Figure IV-2. Average Air Temperatures for Case 03: HF2N3C8



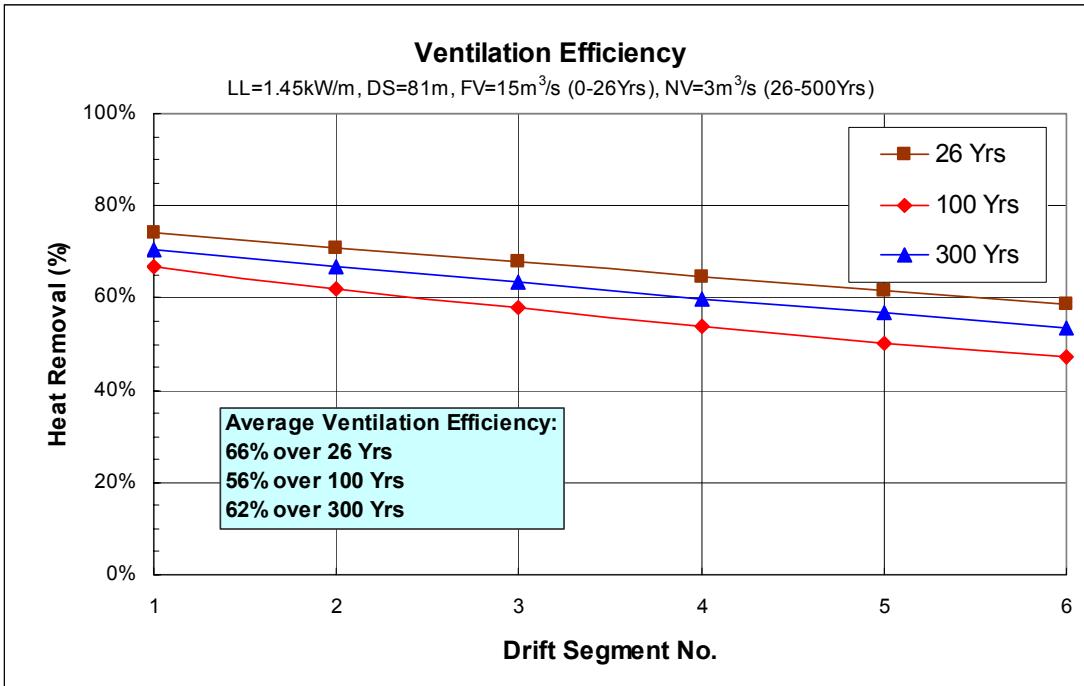
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table IV-3, p. IV-4.

Figure IV-3. Average Waste Package Surface Temperatures for Case 03: HF2N3C8



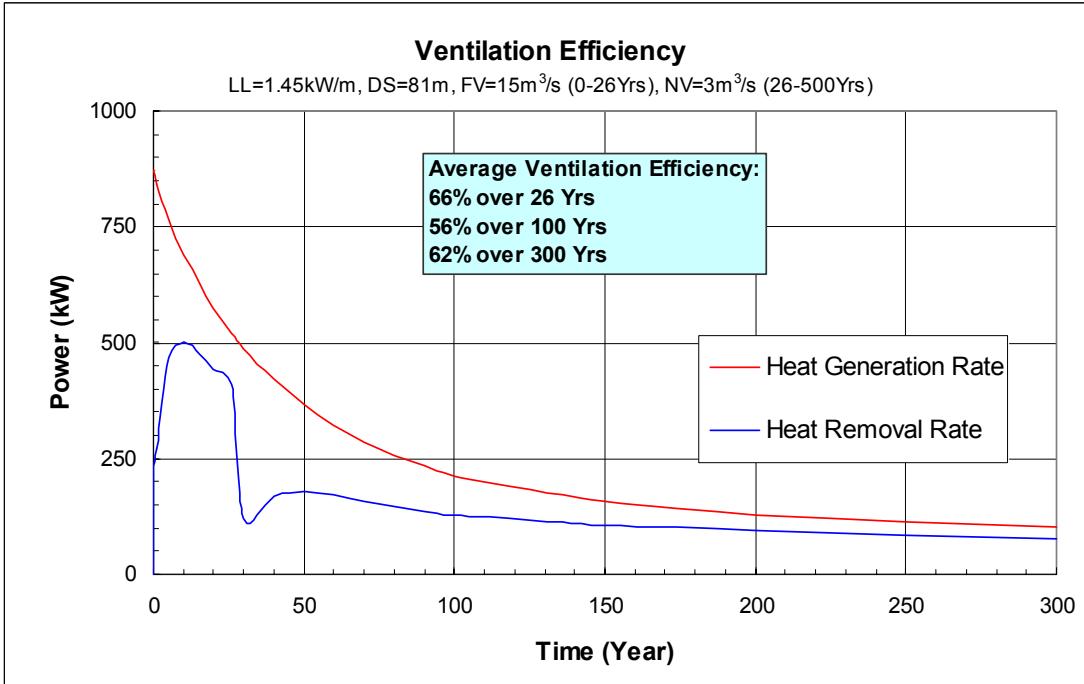
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure IV-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 03: HF2N3C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure IV-5. Average Heat Removal Rates at Different Drift Segments for Case 03: HF2N3C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure IV-6. Overall Heat Generation and Removal Rates at Different Time for Case 03: HF2N3C8

ATTACHMENT V

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 04: HF2N4C8

ATTACHMENT V

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 04: HF2N4C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 26 years and a natural ventilation air flow rate of 4 m³/s from 26 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table V-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 4 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	58.10	65.35	71.70	77.37	82.49	87.19
40.00	57.98	67.67	76.20	83.74	90.41	96.34
50.00	54.50	63.96	72.69	80.70	88.00	94.64
60.00	51.53	60.25	68.43	76.09	83.24	89.89
70.00	49.05	57.07	64.66	71.82	78.57	84.92
80.00	46.94	54.36	61.41	68.10	74.43	80.44
90.00	45.21	52.11	58.69	64.95	70.92	76.59
100.00	43.76	50.22	56.39	62.29	67.93	73.30
125.00	41.53	47.45	53.16	58.65	63.94	69.00
150.00	39.31	44.59	49.75	54.76	59.62	64.33
200.00	37.08	41.69	46.25	50.71	55.09	59.38
250.00	35.73	39.80	43.83	47.82	51.75	55.63
300.00	34.79	38.48	42.14	45.77	49.35	52.90
400.00	33.43	36.73	40.02	43.30	46.55	49.78
500.00	32.43	35.35	38.28	41.21	44.15	47.08

Source: DTN: MO0010MWDANS03.005

Table V-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 4 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	34.61	42.94	50.26	56.79	62.71	68.14
40.00	37.69	48.87	58.71	67.39	75.08	81.91
50.00	36.90	47.94	58.10	67.40	75.86	83.54
60.00	35.67	45.75	55.22	64.09	72.36	80.04
70.00	34.64	43.79	52.47	60.68	68.42	75.71
80.00	33.76	42.13	50.10	57.68	64.88	71.70
90.00	33.03	40.73	48.09	55.13	61.83	68.22
100.00	32.43	39.56	46.42	52.98	59.26	65.26
125.00	31.72	38.24	44.53	50.61	56.45	62.06
150.00	30.87	36.63	42.26	47.75	53.08	58.24
200.00	30.02	35.01	39.93	44.78	49.54	54.20
250.00	29.34	33.67	37.98	42.25	46.47	50.63
300.00	28.91	32.79	36.66	40.49	44.30	48.06
400.00	28.46	31.93	35.40	38.85	42.29	45.70
500.00	28.01	31.05	34.11	37.18	40.26	43.33

Source: DTN: MO0010MWDANS03.005

Table V-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 4 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	76.54	83.06	88.79	93.92	98.57	102.84
40.00	73.64	82.51	90.38	97.35	103.56	109.08
50.00	68.48	77.21	85.31	92.77	99.61	105.86
60.00	64.13	72.22	79.87	87.05	93.78	100.06
70.00	60.47	67.97	75.09	81.85	88.23	94.26
80.00	57.37	64.34	70.99	77.33	83.34	89.06
90.00	54.83	61.34	67.57	73.52	79.21	84.62
100.00	52.68	58.80	64.66	70.30	75.68	80.83
125.00	49.38	55.03	60.49	65.76	70.83	75.71
150.00	46.04	51.11	56.07	60.90	65.60	70.15
200.00	42.76	47.21	51.62	55.94	60.19	64.35
250.00	40.78	44.71	48.62	52.49	56.32	60.09
300.00	39.38	42.96	46.52	50.05	53.53	56.99
400.00	37.35	40.56	43.78	46.98	50.16	53.32
500.00	35.86	38.71	41.57	44.44	47.32	50.19

Source: DTN: MO0010MWDANS03.005

Table V-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-26 Years), and 4 m³/s (26-500 Years) (Drift Spacing = 81 m)

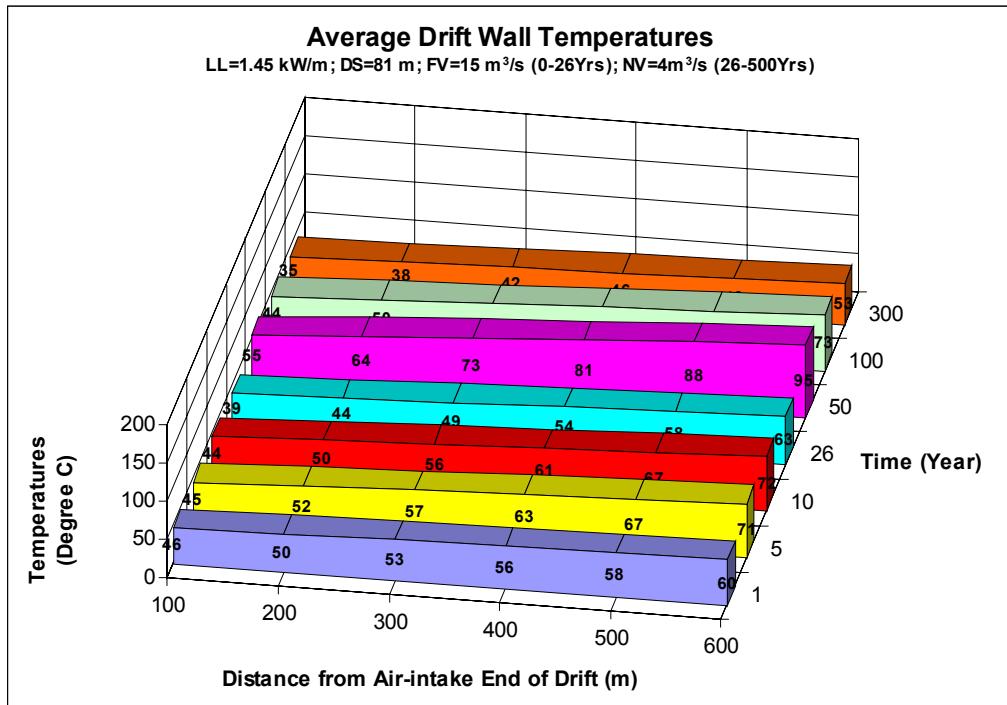
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	33.79	29.27	25.74	22.98	20.81	19.10
40.00	44.63	39.30	34.60	30.52	27.02	24.04
50.00	41.85	38.82	35.73	32.68	29.76	27.01
60.00	37.53	35.42	33.31	31.18	29.07	27.00
70.00	33.88	32.19	30.52	28.86	27.23	25.63
80.00	30.81	29.41	28.03	26.66	25.31	23.99
90.00	28.24	27.06	25.90	24.73	23.58	22.45
100.00	26.11	25.10	24.09	23.08	22.08	21.10
125.00	23.64	22.91	22.14	21.35	20.54	19.73
150.00	20.65	20.25	19.80	19.29	18.74	18.15
200.00	17.66	17.52	17.32	17.05	16.73	16.37
250.00	15.27	15.22	15.14	15.01	14.84	14.64
300.00	13.73	13.67	13.59	13.49	13.37	13.23

Source: DTN: MO0010MWDANS03.005

Table V-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-26 Years), and 4 m³/s (26-500 Years) (Drift Spacing = 81 m)

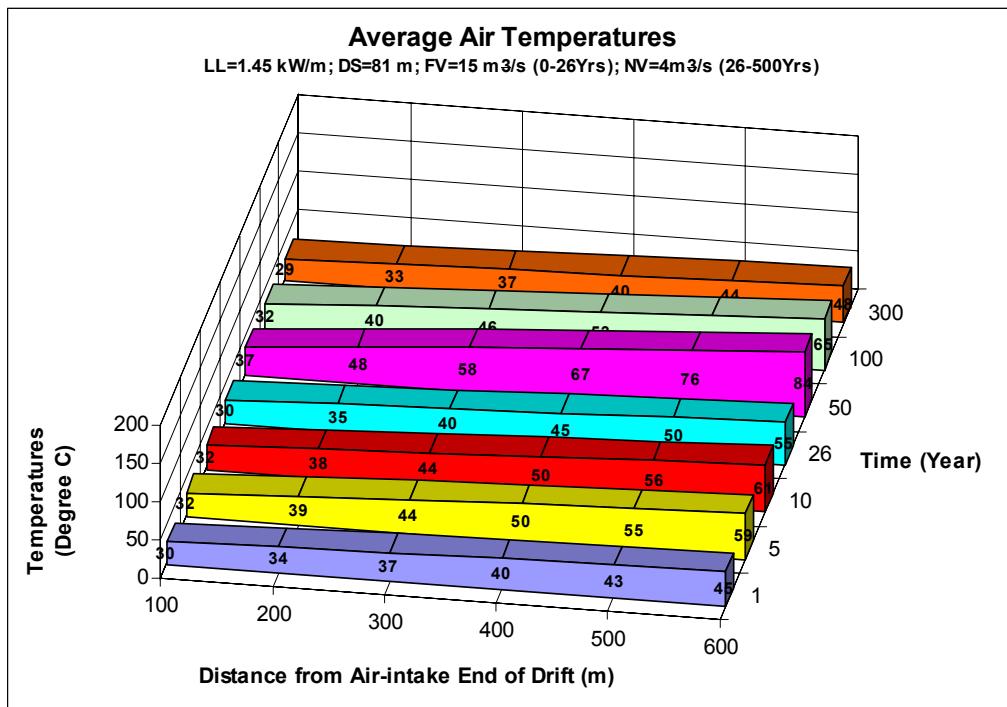
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	151.70	281.28	35481.34				
40.00	48.24%	419.68	453.93	143151.62	40.00	200.12	175.91	55473.96				
50.00	41.94%	364.89	392.29	123711.69	50.00	205.84	202.98	64011.58				
60.00	36.88%	320.81	342.85	108121.88	60.00	193.52	199.68	62970.95				
70.00	32.81%	285.42	303.12	95590.81	70.00	178.31	185.91	58629.50				
80.00	29.47%	256.40	270.91	85434.15	80.00	164.21	171.26	54007.51				
90.00	26.76%	232.84	244.62	77142.91	90.00	151.97	158.09	49853.93				
100.00	24.52%	213.32	223.08	70349.62	100.00	141.57	146.77	46284.16				
125.00	21.21%	184.50	198.91	156819.84	125.00	130.31	135.94	107174.16				
150.00	17.89%	155.68	170.09	134098.48	150.00	116.88	123.59	97441.61				
200.00	14.85%	129.19	142.43	224589.03	200.00	102.66	109.77	173081.07				
250.00	13.03%	113.33	121.26	191201.22	250.00	90.13	96.39	151992.71				
300.00	11.76%	102.34	107.84	170036.07	300.00	81.07	85.60	134975.72				
Total heat generated in 26 years (GJ)				545987.77	Total heat removed in 26 years (GJ)		361959.13					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		788672.07					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1453337.34					
Percentage of total heat removal in 26 years = 66%												
Percentage of total heat removal in 100 years = 60%												
Percentage of total heat removal in 300 years = 66%												

Source: DTN: MO0010MWDANS03.005



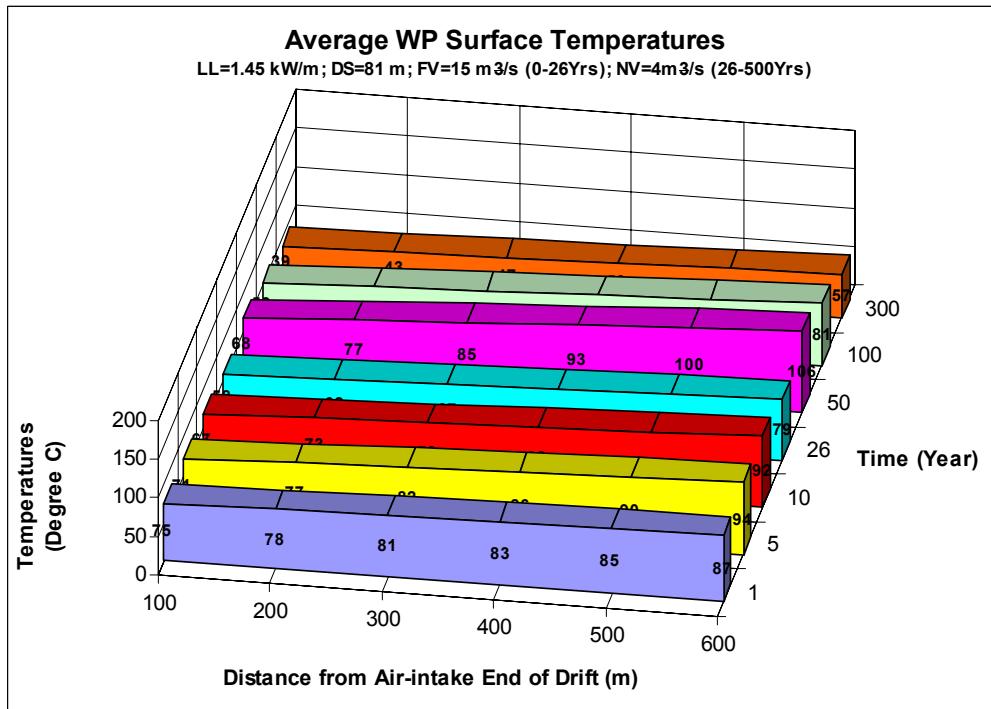
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table V-1, p. V-2.

Figure V-1. Average Drift Wall Temperatures for Case 04: HF2N4C8



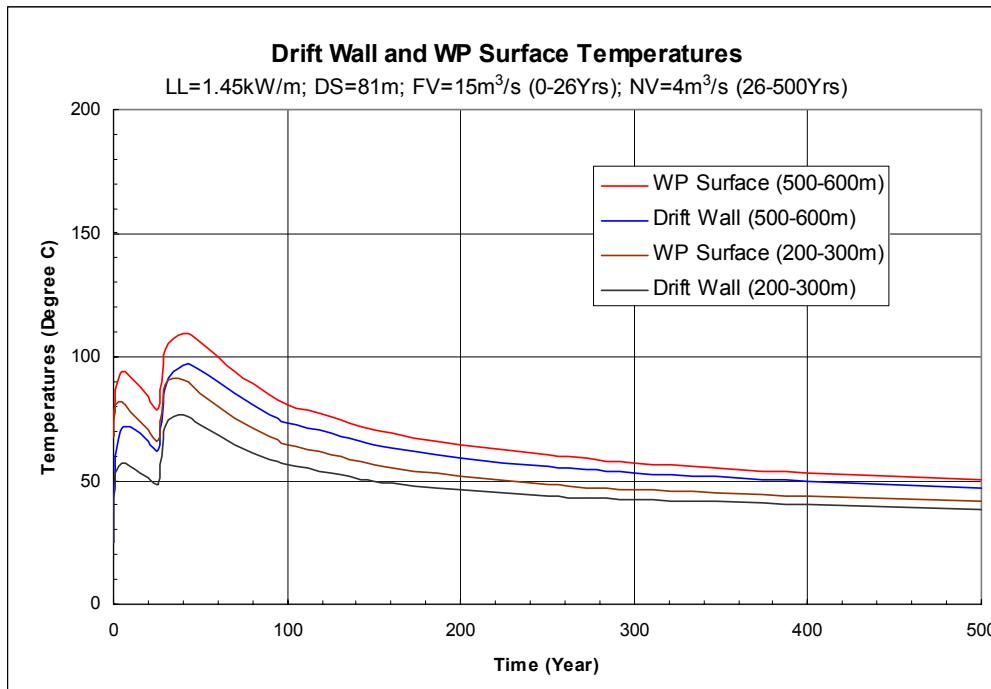
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table V-2, p. V-3.

Figure V-2. Average Air Temperatures for Case 04: HF2N4C8



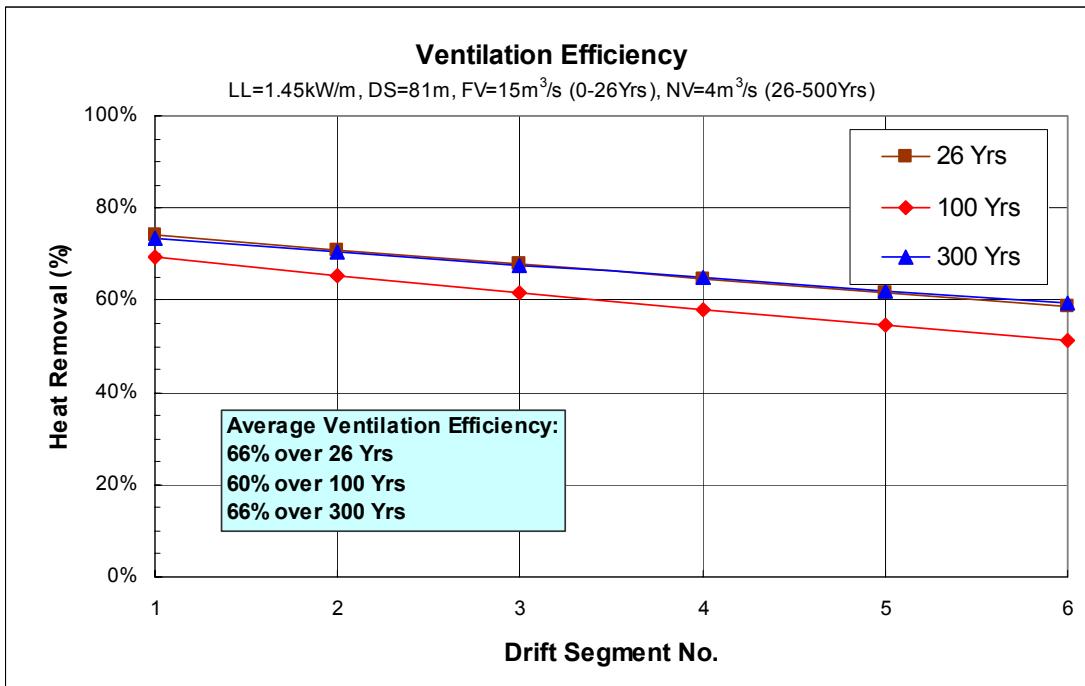
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table V-3, p. V-4.

Figure V-3. Average Waste Package Surface Temperatures for Case 04: HF2N4C8



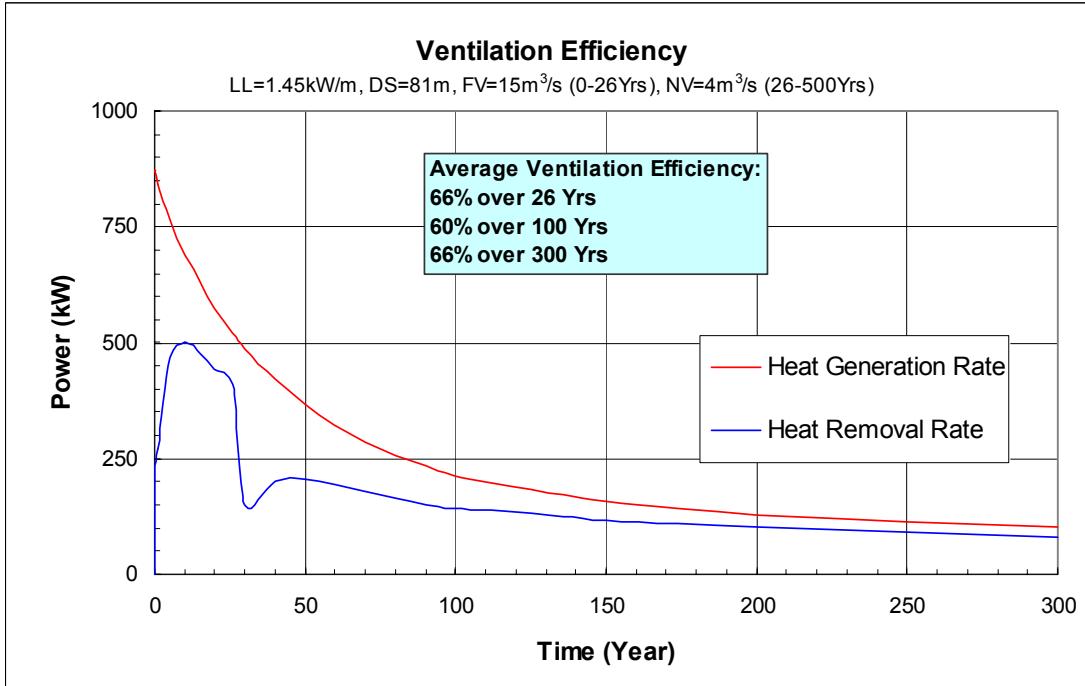
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure V-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 04: HF2N4C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure V-5. Average Heat Removal Rates at Different Drift Segments for Case 04: HF2N4C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure V-6. Overall Heat Generation and Removal Rates at Different Time for Case 04: HF2N4C8

ATTACHMENT VI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 05: HF2N5C8

ATTACHMENT VI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 05: HF2N5C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 26 years and a natural ventilation air flow rate of 5 m³/s from 26 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table VI-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 5 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	54.29	61.06	67.12	72.63	77.70	82.40
40.00	53.25	61.89	69.66	76.67	83.01	88.75
50.00	50.14	58.37	66.11	73.35	80.08	86.32
60.00	47.53	55.04	62.21	69.04	75.50	81.62
70.00	45.35	52.22	58.82	65.14	71.19	76.96
80.00	43.52	49.84	55.93	61.79	67.42	72.82
90.00	42.02	47.87	53.53	58.98	64.25	69.31
100.00	40.77	46.22	51.51	56.62	61.56	66.33
125.00	38.85	43.83	48.68	53.41	58.01	62.47
150.00	36.94	41.36	45.71	49.99	54.18	58.29
200.00	35.05	38.87	42.67	46.46	50.19	53.89
250.00	33.90	37.26	40.60	43.95	47.27	50.58
300.00	33.10	36.14	39.16	42.18	45.20	48.18
400.00	31.96	34.66	37.37	40.07	42.79	45.49
500.00	31.13	33.50	35.90	38.31	40.74	43.17

Source: DTN: MO0010MWDANS03.005

Table VI-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 5 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	33.58	41.18	48.02	54.24	59.97	65.29
40.00	35.76	45.45	54.18	62.06	69.19	75.65
50.00	34.91	44.28	53.07	61.28	68.90	75.95
60.00	33.85	42.33	50.44	58.15	65.47	72.38
70.00	32.96	40.63	48.01	55.10	61.88	68.36
80.00	32.22	39.20	45.95	52.45	58.71	64.73
90.00	31.60	38.01	44.21	50.22	56.02	61.61
100.00	31.09	37.02	42.77	48.35	53.75	58.98
125.00	30.50	35.89	41.16	46.29	51.29	56.15
150.00	29.79	34.53	39.22	43.83	48.36	52.79
200.00	29.08	33.16	37.24	41.28	45.29	49.26
250.00	28.52	32.05	35.59	39.13	42.66	46.17
300.00	28.16	31.32	34.48	37.65	40.80	43.95
400.00	27.80	30.61	33.43	36.27	39.10	41.94
500.00	27.43	29.89	32.37	34.88	37.40	39.93

Source: DTN: MO0010MWDANS03.005

Table VI-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-26 Years), and 5 m³/s (26-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	72.80	78.87	84.34	89.33	93.92	98.20
40.00	69.13	77.01	84.16	90.63	96.51	101.84
50.00	64.27	71.85	79.02	85.75	92.04	97.90
60.00	60.23	67.20	73.88	80.27	86.35	92.11
70.00	56.86	63.27	69.45	75.40	81.11	86.58
80.00	54.01	59.94	65.68	71.22	76.55	81.69
90.00	51.68	57.19	62.54	67.72	72.73	77.56
100.00	49.71	54.87	59.90	64.76	69.48	74.04
125.00	46.70	51.45	56.09	60.62	65.02	69.31
150.00	43.66	47.90	52.08	56.20	60.25	64.21
200.00	40.71	44.40	48.07	51.74	55.36	58.94
250.00	38.93	42.17	45.41	48.65	51.89	55.10
300.00	37.67	40.61	43.55	46.48	49.41	52.32
400.00	35.86	38.49	41.13	43.77	46.42	49.06
500.00	34.53	36.85	39.19	41.55	43.93	46.31

Source: DTN: MO0010MWDANS03.005

Table VI-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-26 Years), and 5 m³/s (26-500 Years) (Drift Spacing = 81 m)

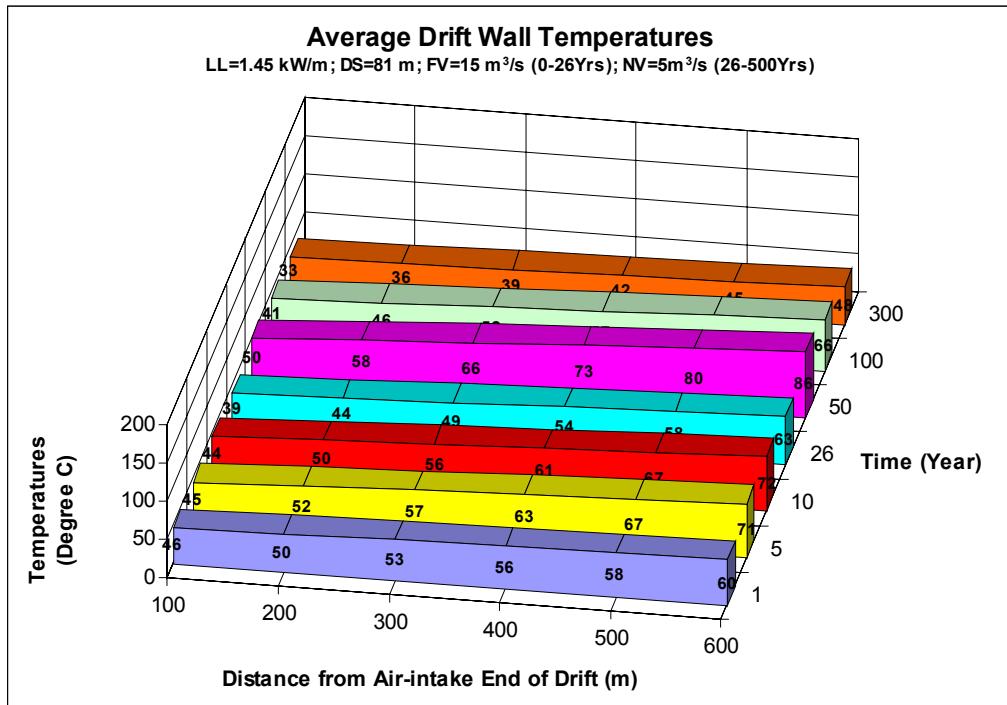
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	38.03	33.74	30.31	27.58	25.38	23.60
40.00	47.69	42.98	38.72	34.93	31.60	28.67
50.00	43.94	41.55	38.99	36.38	33.79	31.28
60.00	39.24	37.61	35.93	34.21	32.45	30.66
70.00	35.31	34.02	32.71	31.41	30.08	28.74
80.00	32.02	30.96	29.90	28.83	27.76	26.68
90.00	29.28	28.40	27.51	26.62	25.71	24.81
100.00	27.02	26.26	25.51	24.74	23.96	23.18
125.00	24.40	23.89	23.35	22.77	22.17	21.54
150.00	21.24	21.03	20.77	20.45	20.08	19.67
200.00	18.10	18.10	18.05	17.95	17.78	17.58
250.00	15.60	15.66	15.69	15.69	15.64	15.57
300.00	14.00	14.02	14.03	14.02	14.00	13.96

Source: DTN: MO0010MWDANS03.005

Table VI-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-26 Years), and 5 m³/s (26-500 Years) (Drift Spacing = 81 m)

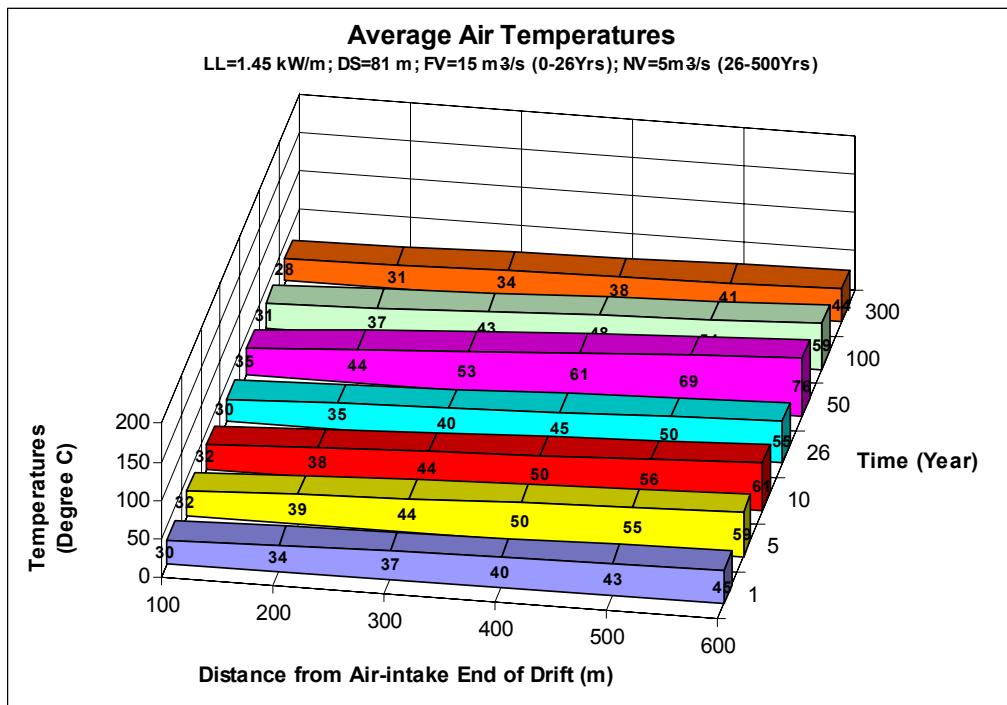
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	178.64	294.75	37180.66				
40.00	48.24%	419.68	453.93	143151.62	40.00	224.60	201.62	63582.06				
50.00	41.94%	364.89	392.29	123711.69	50.00	225.93	225.26	71039.45				
60.00	36.88%	320.81	342.85	108121.88	60.00	210.10	218.02	68753.82				
70.00	32.81%	285.42	303.12	95590.81	70.00	192.27	201.18	63445.33				
80.00	29.47%	256.40	270.91	85434.15	80.00	176.15	184.21	58091.87				
90.00	26.76%	232.84	244.62	77142.91	90.00	162.33	169.24	53371.46				
100.00	24.52%	213.32	223.08	70349.62	100.00	150.67	156.50	49353.98				
125.00	21.21%	184.50	198.91	156819.84	125.00	138.13	144.40	113843.84				
150.00	17.89%	155.68	170.09	134098.48	150.00	123.23	130.68	103026.96				
200.00	14.85%	129.19	142.43	224589.03	200.00	107.56	115.40	181958.14				
250.00	13.03%	113.33	121.26	191201.22	250.00	93.86	100.71	158800.63				
300.00	11.76%	102.34	107.84	170036.07	300.00	84.03	88.94	140248.07				
Total heat generated in 26 years (GJ)				545987.77	Total heat removed in 26 years (GJ)		361959.13					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		826777.75					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1524655.38					
Percentage of total heat removal in 26 years = 66%												
Percentage of total heat removal in 100 years = 63%												
Percentage of total heat removal in 300 years = 70%												

Source: DTN: MO0010MWDANS03.005



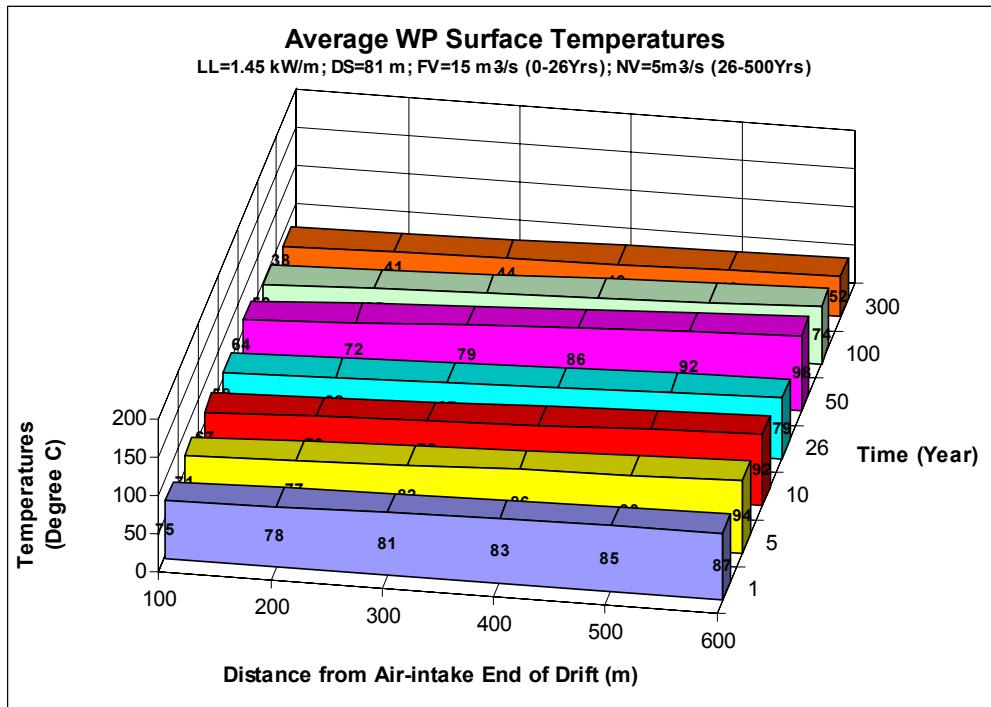
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table VI-1, p. VI-2.

Figure VI-1. Average Drift Wall Temperatures for Case 05: HF2N5C8



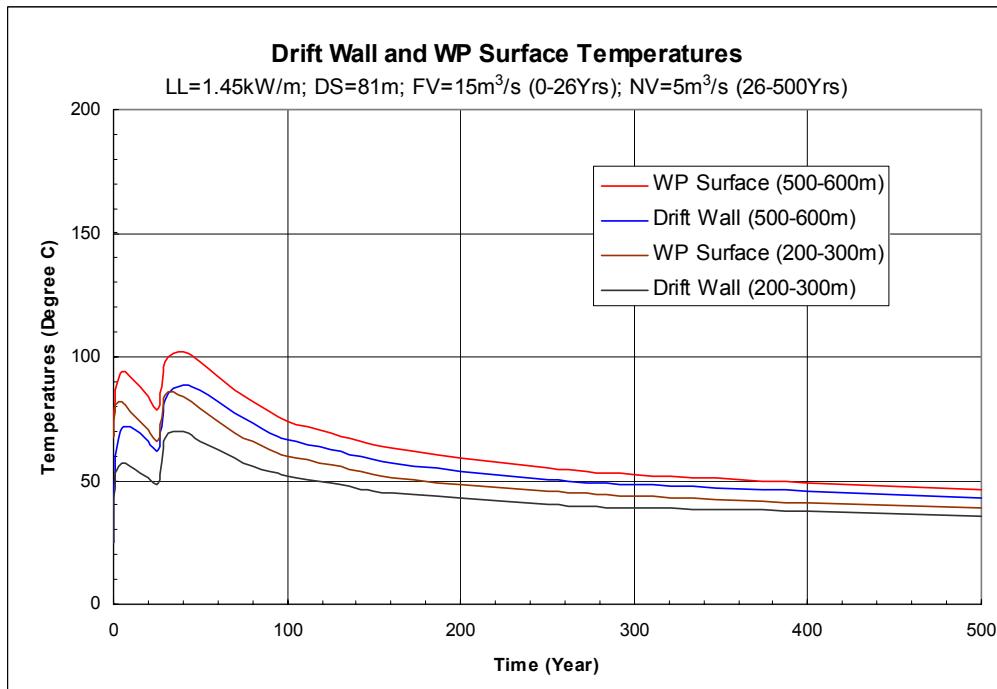
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table VI-2, p. VI-3.

Figure VI-2. Average Air Temperatures for Case 05: HF2N5C8



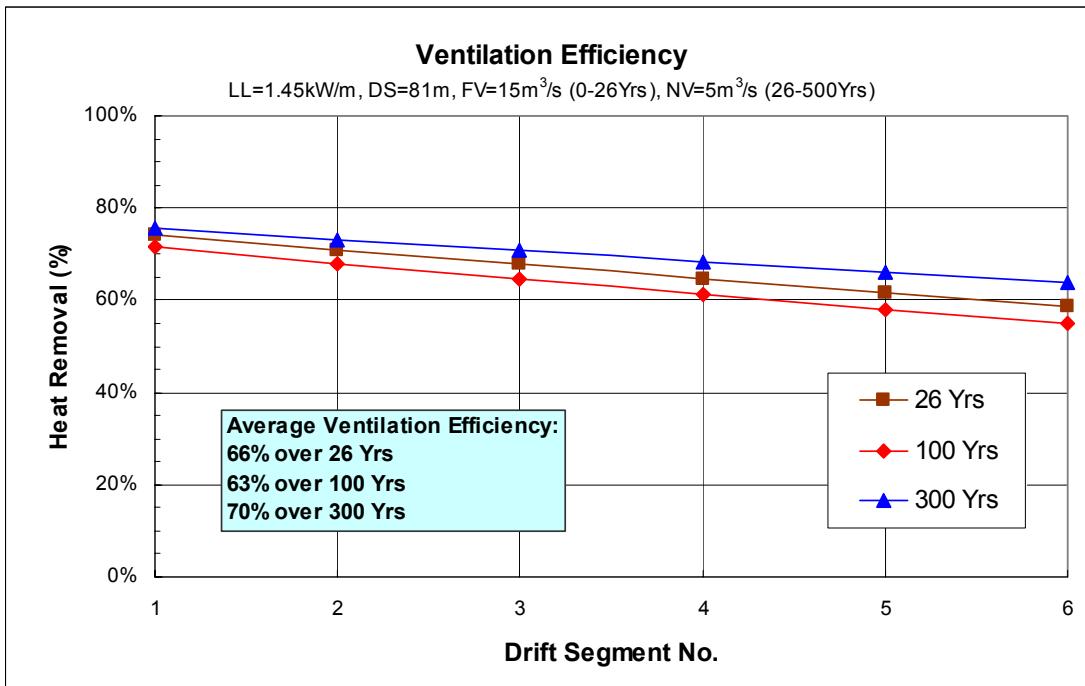
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table VI-3, p. VI-4.

Figure VI-3. Average Waste Package Surface Temperatures for Case 05: HF2N5C8



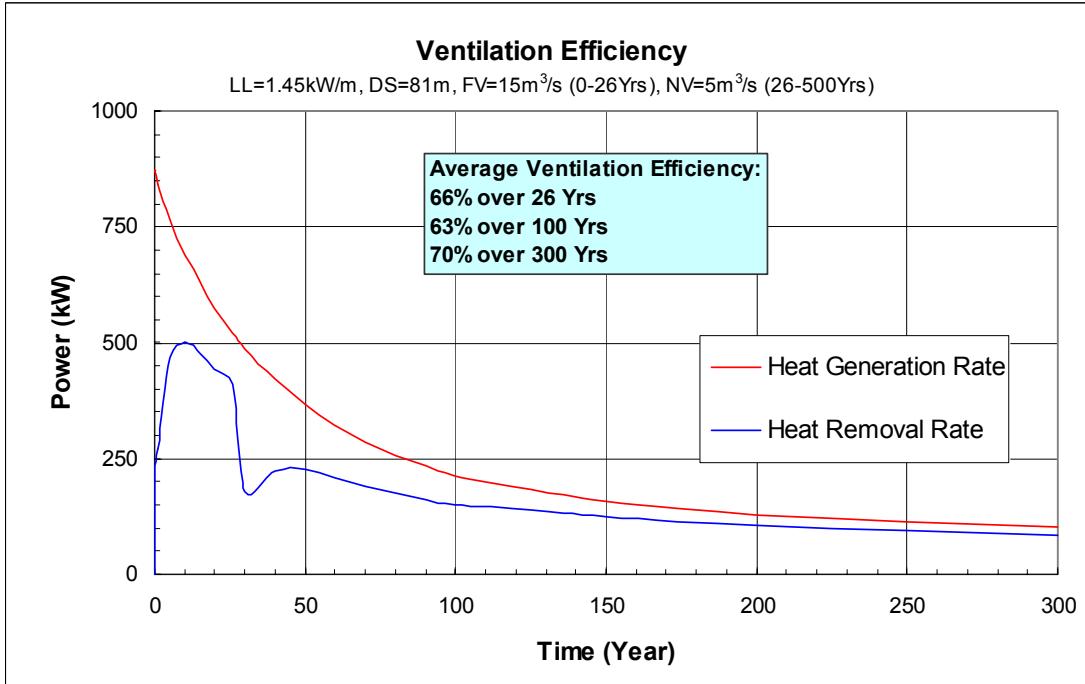
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VI-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 05: HF2N5C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VI-5. Average Heat Removal Rates at Different Drift Segments for Case 05: HF2N5C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VI-6. Overall Heat Generation and Removal Rates at Different Time for Case 05: HF2N5C8

ATTACHMENT VII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 06: HF5N1C8

ATTACHMENT VII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 06: HF5N1C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and a natural ventilation air flow rate of 1 m³/s from 50 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table VII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 1 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	66.73	74.29	80.07	84.66	88.48	91.78
70.00	72.84	83.77	91.96	98.13	105.17	108.87
80.00	70.72	82.83	92.22	99.52	106.82	113.00
90.00	68.42	80.51	90.15	97.85	105.32	111.70
100.00	66.28	78.16	87.76	95.54	101.67	108.87
125.00	62.98	74.69	84.29	92.18	98.51	104.76
150.00	59.16	70.36	79.71	87.54	93.97	99.12
200.00	55.20	65.80	74.85	82.57	89.05	94.42
250.00	52.70	62.69	71.38	78.90	85.33	90.77
300.00	50.85	60.40	68.78	76.12	82.47	87.93
400.00	48.07	57.13	65.22	72.40	78.72	84.24
500.00	45.90	54.38	62.07	69.03	75.24	80.74

Source: DTN: MO0010MWDANS03.005

Table VII-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 1 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	38.29	47.98	55.32	61.13	65.92	70.05
70.00	46.79	62.76	74.56	83.37	90.60	96.10
80.00	47.55	64.97	78.38	88.69	97.53	104.56
90.00	46.44	63.54	77.10	87.85	97.03	104.84
100.00	45.35	61.81	75.08	85.78	94.66	102.55
125.00	44.02	59.68	72.51	83.02	91.54	99.21
150.00	42.29	56.85	69.04	79.22	87.63	94.79
200.00	40.40	53.69	65.08	74.79	82.98	89.82
250.00	38.83	51.01	61.65	70.88	78.82	85.58
300.00	37.78	49.15	59.20	68.03	75.72	82.38
400.00	36.66	47.22	56.69	65.13	72.60	79.14
500.00	35.47	45.14	53.98	61.99	69.19	75.61

Source: DTN: MO0010MWDANS03.005

Table VII-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 1 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	79.63	86.63	92.00	96.26	99.81	102.88
70.00	83.61	93.98	101.76	107.62	114.38	117.92
80.00	80.52	92.03	101.00	107.99	115.04	120.89
90.00	77.45	89.00	98.23	105.63	112.87	118.94
100.00	74.69	86.06	95.28	102.78	108.63	115.57
125.00	70.41	81.67	90.94	98.57	104.71	110.81
150.00	65.58	76.41	85.48	93.09	99.35	104.38
200.00	60.66	70.96	79.77	87.30	93.64	98.90
250.00	57.56	67.29	75.77	83.13	89.43	94.77
300.00	55.29	64.60	72.80	79.99	86.23	91.58
400.00	51.89	60.75	68.69	75.74	81.96	87.40
500.00	49.26	57.57	65.13	71.97	78.09	83.53

Source: DTN: MO0010MWDANS03.005

Table VII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), and 1 m³/s (50-500 Years) (Drift Spacing = 81 m)

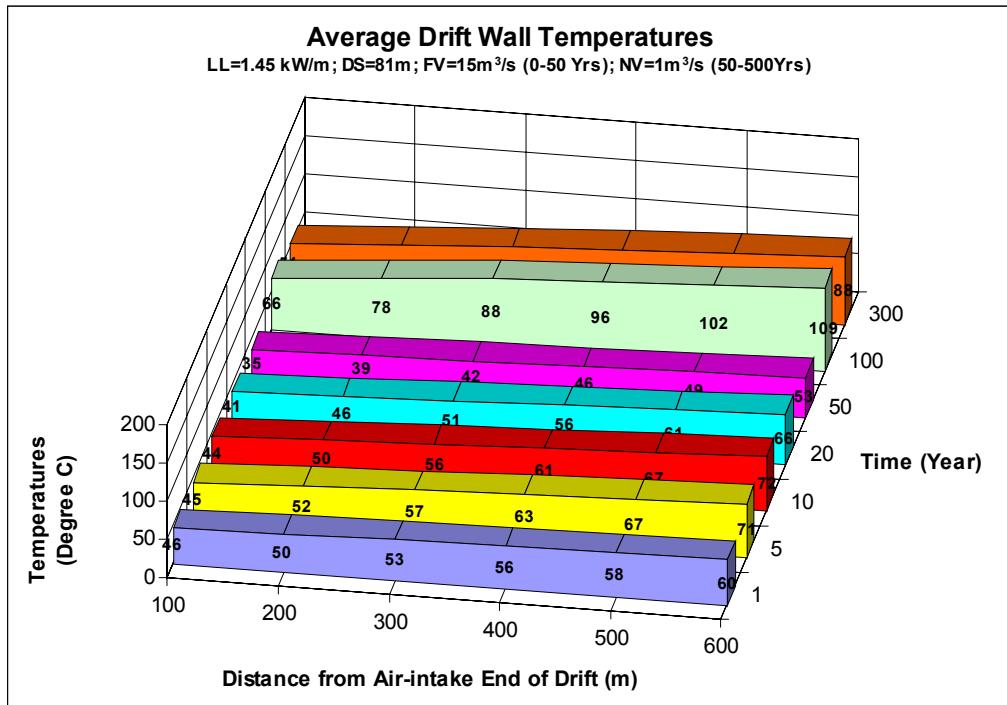
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	10.87	7.93	6.01	4.75	3.92	3.38
70.00	17.83	13.06	9.65	7.21	5.91	4.50
80.00	18.45	14.25	10.97	8.43	7.23	5.75
90.00	17.54	13.98	11.10	8.79	7.51	6.39
100.00	16.65	13.46	10.86	8.75	7.26	6.45
125.00	15.56	12.80	10.50	8.60	6.97	6.27
150.00	14.14	11.91	9.98	8.33	6.88	5.85
200.00	12.60	10.88	9.32	7.94	6.70	5.59
250.00	11.32	9.96	8.70	7.55	6.50	5.53
300.00	10.45	9.30	8.22	7.22	6.30	5.44

Source: DTN: MO0010MWDANS03.005

Table VII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), and 1 m³/s (50-500 Years) (Drift Spacing = 81 m)

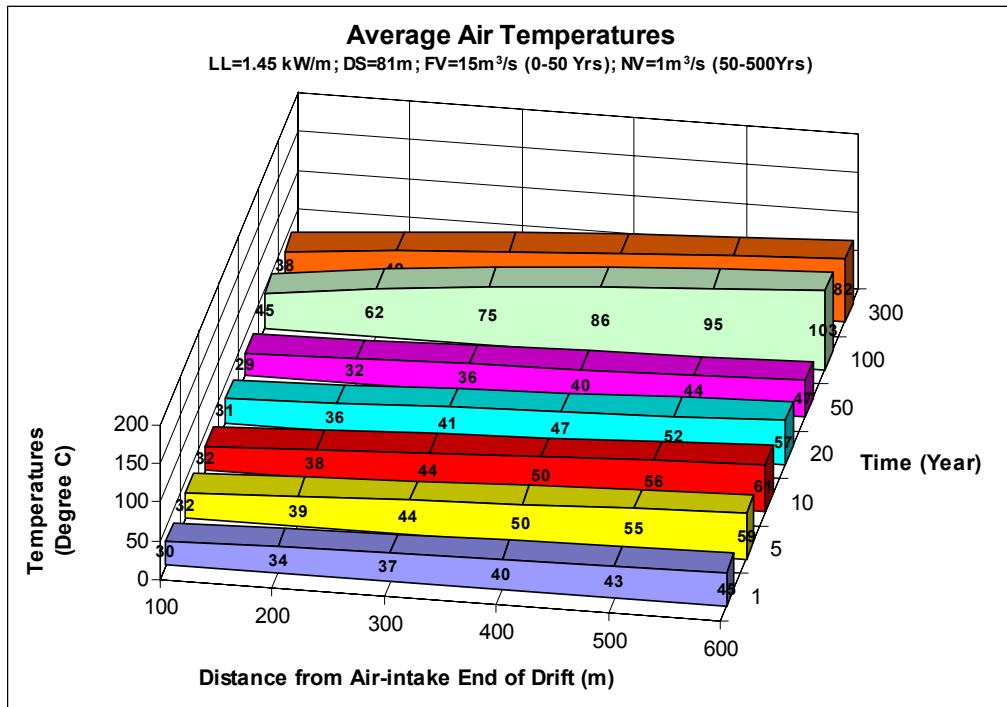
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07			
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31			
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37			
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24			
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48			
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32			
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75			
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73			
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19			
60.00	36.88%	320.81	342.85	108121.88	60.00	36.85	172.54	54412.16			
70.00	32.81%	285.42	303.12	95590.81	70.00	58.16	47.50	14980.94			
80.00	29.47%	256.40	270.91	85434.15	80.00	65.08	61.62	19431.55			
90.00	26.76%	232.84	244.62	77142.91	90.00	65.31	65.19	20559.43			
100.00	24.52%	213.32	223.08	70349.62	100.00	63.44	64.37	20300.84			
125.00	21.21%	184.50	198.91	156819.84	125.00	60.70	62.07	48935.45			
150.00	17.89%	155.68	170.09	134098.48	150.00	57.09	58.89	46431.44			
200.00	14.85%	129.19	142.43	224589.03	200.00	53.02	55.05	86807.37			
250.00	13.03%	113.33	121.26	191201.22	250.00	49.56	51.29	80872.61			
300.00	11.76%	102.34	107.84	170036.07	300.00	46.93	48.25	76074.20			
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)			630434.80			
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)			760119.74			
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)			1099240.79			
Percentage of total heat removal in 50 years = 72%											
Percentage of total heat removal in 100 years = 58%											
Percentage of total heat removal in 300 years = 50%											

Source: DTN: MO0010MWDANS03.005



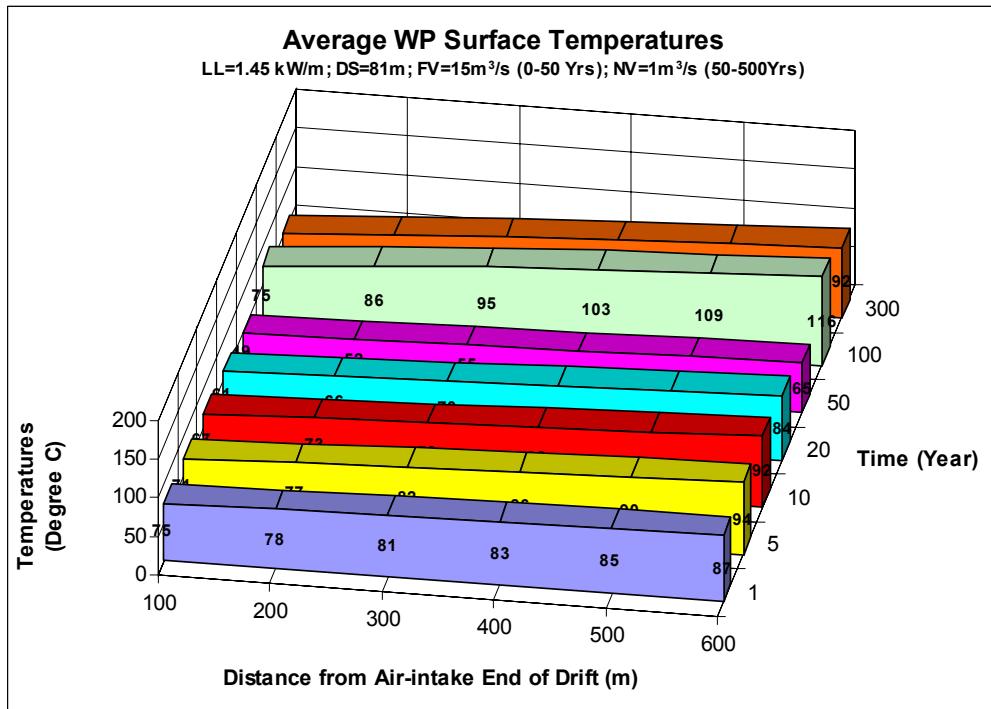
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table VII-1, p. VII-2.

Figure VII-1. Average Drift Wall Temperatures for Case 06: HF5N1C8



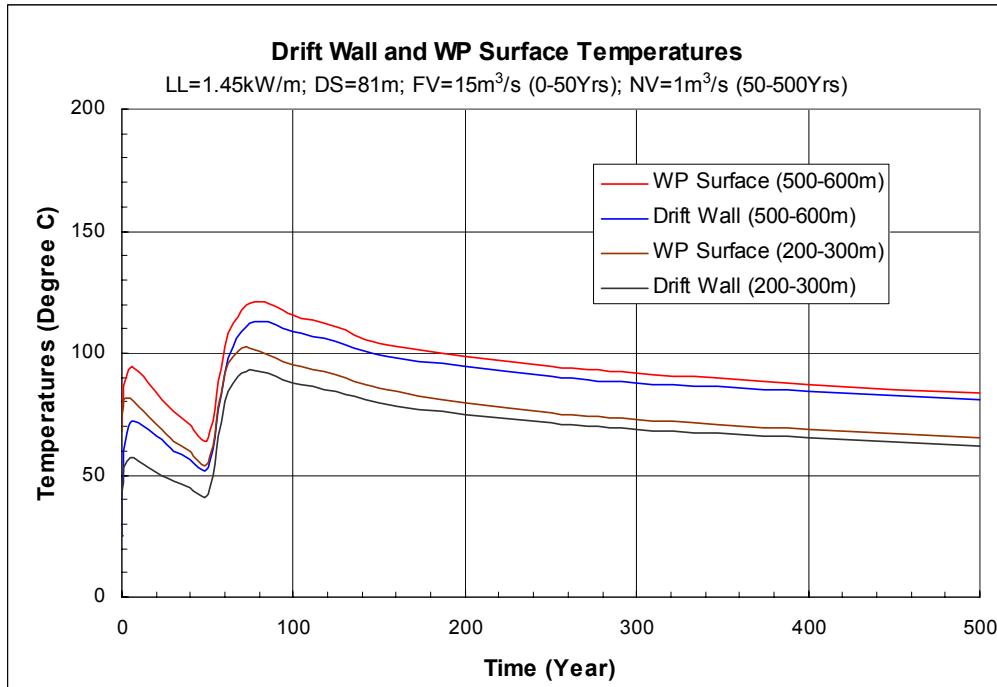
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table VII-2, p. VII-3.

Figure VII-2. Average Air Temperatures for Case 06: HF5N1C8



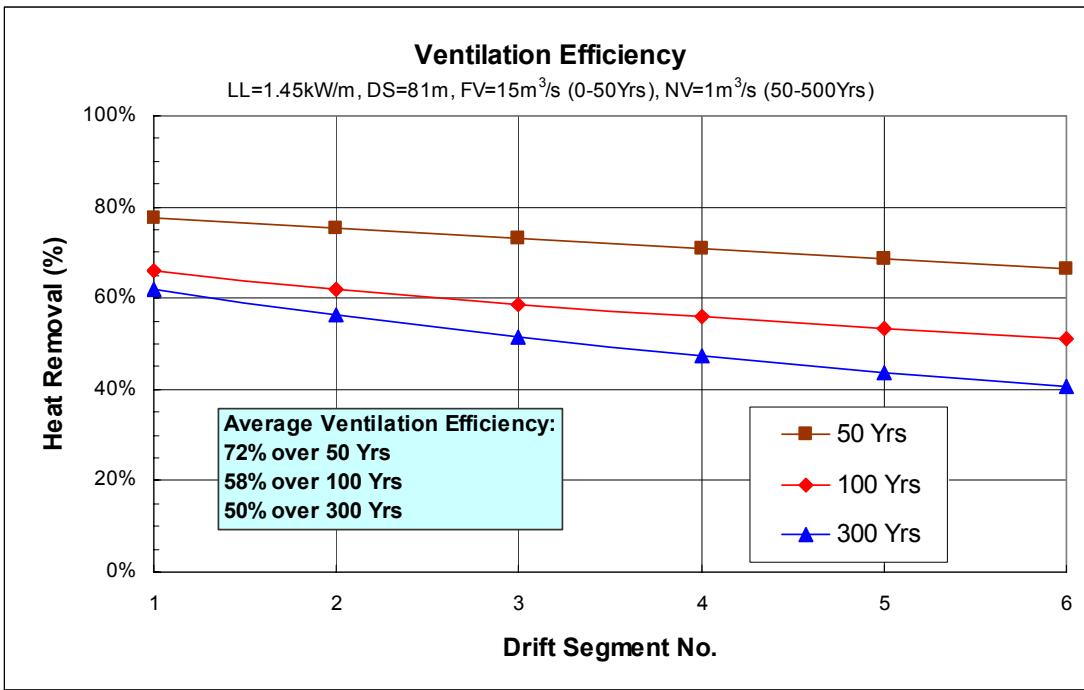
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table VII-3, p. VII-4.

Figure VII-3. Average Waste Package Surface Temperatures for Case 06: HF5N1C8



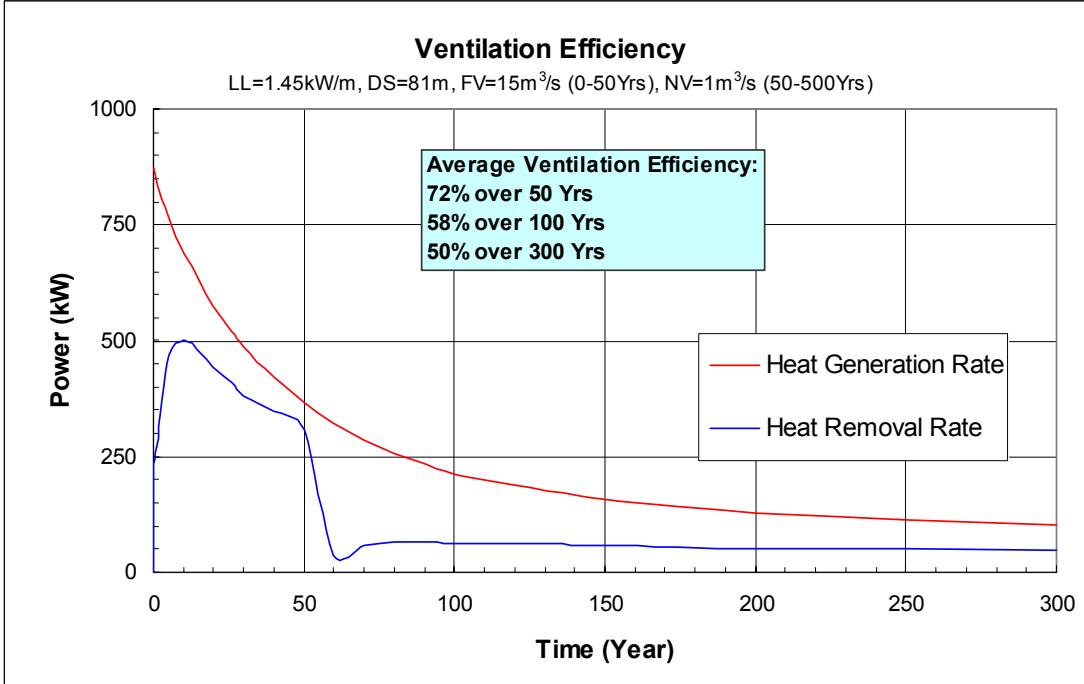
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 06: HF5N1C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VII-5. Average Heat Removal Rates at Different Drift Segments for Case 06: HF5N1C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VII-6. Overall Heat Generation and Removal Rates at Different Time for Case 06: HF5N1C8

ATTACHMENT VIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 07: HF5N2C8

ATTACHMENT VIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 07: HF5N2C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and a natural ventilation air flow rate of 2 m³/s from 50 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table VIII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 2 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	57.78	64.36	69.82	74.45	78.49	82.11
70.00	59.54	68.89	76.61	83.04	88.44	93.04
80.00	57.36	67.09	75.49	82.73	88.94	94.29
90.00	55.31	64.74	73.05	80.37	86.79	92.43
100.00	53.50	62.56	70.63	77.81	84.19	89.85
125.00	50.70	59.34	67.14	74.16	80.47	86.13
150.00	47.67	55.68	63.01	69.70	75.80	81.34
200.00	44.60	51.88	58.65	64.95	70.77	76.13
250.00	42.69	49.32	55.57	61.45	66.94	72.07
300.00	41.31	47.48	53.33	58.86	64.07	68.98
400.00	39.28	44.96	50.39	55.58	60.52	65.20
500.00	37.75	42.89	47.89	52.71	57.34	61.78

Source: DTN: MO0010MWDANS03.005

Table VIII-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 2 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	34.71	42.54	49.02	54.52	59.32	63.60
70.00	39.44	51.26	60.97	68.99	75.68	81.32
80.00	39.23	51.55	62.15	71.22	78.97	85.60
90.00	38.31	50.10	60.49	69.61	77.60	84.57
100.00	37.48	48.63	58.58	67.43	75.28	82.24
125.00	36.49	46.90	56.29	64.75	72.35	79.16
150.00	35.24	44.69	53.36	61.30	68.53	75.09
200.00	33.94	42.33	50.18	57.47	64.22	70.44
250.00	32.87	40.36	47.45	54.12	60.38	66.23
300.00	32.17	39.02	45.54	51.72	57.57	63.07
400.00	31.45	37.67	43.65	49.38	54.84	60.02
500.00	30.69	36.26	41.68	46.92	51.98	56.83

Source: DTN: MO0010MWDANS03.005

Table VIII-3. Average Waste Package Surface Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), and 2 m^3/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	70.88	76.98	82.04	86.35	90.11	93.48
70.00	70.86	79.68	86.99	93.08	98.21	102.57
80.00	67.67	76.88	84.86	91.76	97.69	102.81
90.00	64.82	73.77	81.70	88.70	94.85	100.26
100.00	62.33	70.96	78.68	85.56	91.69	97.14
125.00	58.48	66.76	74.26	81.02	87.10	92.58
150.00	54.38	62.08	69.17	75.65	81.57	86.95
200.00	50.27	57.31	63.89	70.02	75.68	80.92
250.00	47.73	54.16	60.25	65.98	71.34	76.35
300.00	45.90	51.91	57.61	63.01	68.10	72.90
400.00	43.22	48.76	54.07	59.15	64.00	68.60
500.00	41.20	46.23	51.13	55.86	60.41	64.78

Source: DTN: MO0010MWDANS03.005

Table VIII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), and 2 m³/s (50-500 Years) (Drift Spacing = 81 m)

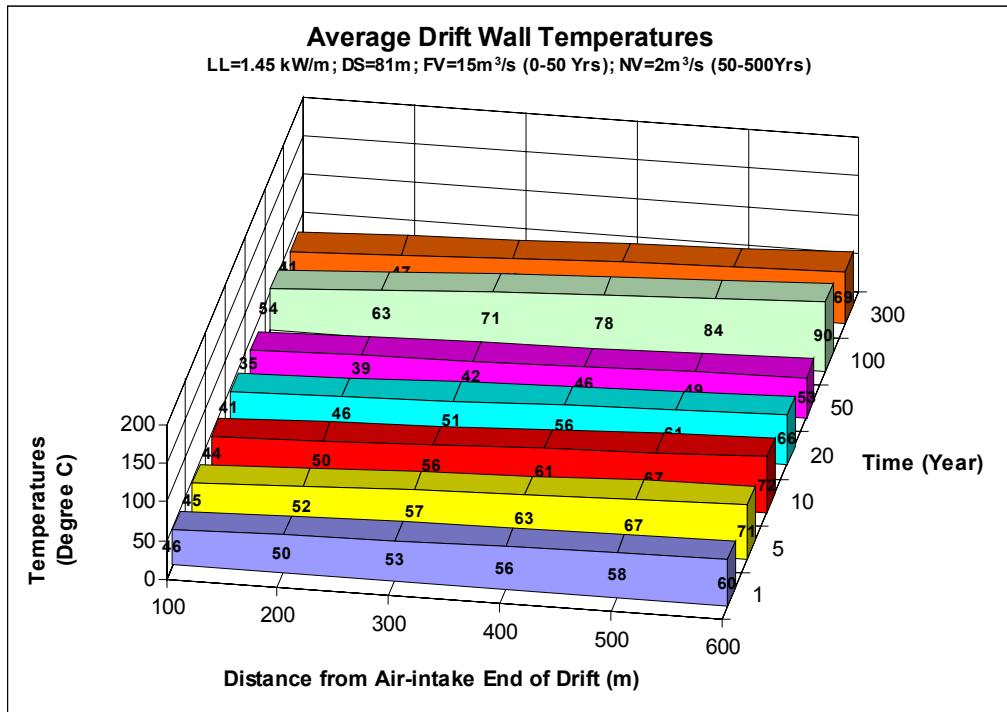
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	16.53	13.33	11.03	9.37	8.16	7.29
70.00	24.58	20.13	16.53	13.66	11.39	9.61
80.00	24.23	20.98	18.04	15.44	13.20	11.29
90.00	22.66	20.07	17.69	15.53	13.60	11.88
100.00	21.25	18.99	16.93	15.07	13.37	11.85
125.00	19.56	17.72	16.00	14.40	12.94	11.60
150.00	17.43	16.09	14.77	13.51	12.31	11.18
200.00	15.21	14.30	13.36	12.42	11.49	10.59
250.00	13.40	12.75	12.06	11.37	10.66	9.95
300.00	12.21	11.66	11.10	10.53	9.95	9.37

Source: DTN: MO0010MWDANS03.005

Table VIII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), and 2 m³/s (50-500 Years) (Drift Spacing = 81 m)

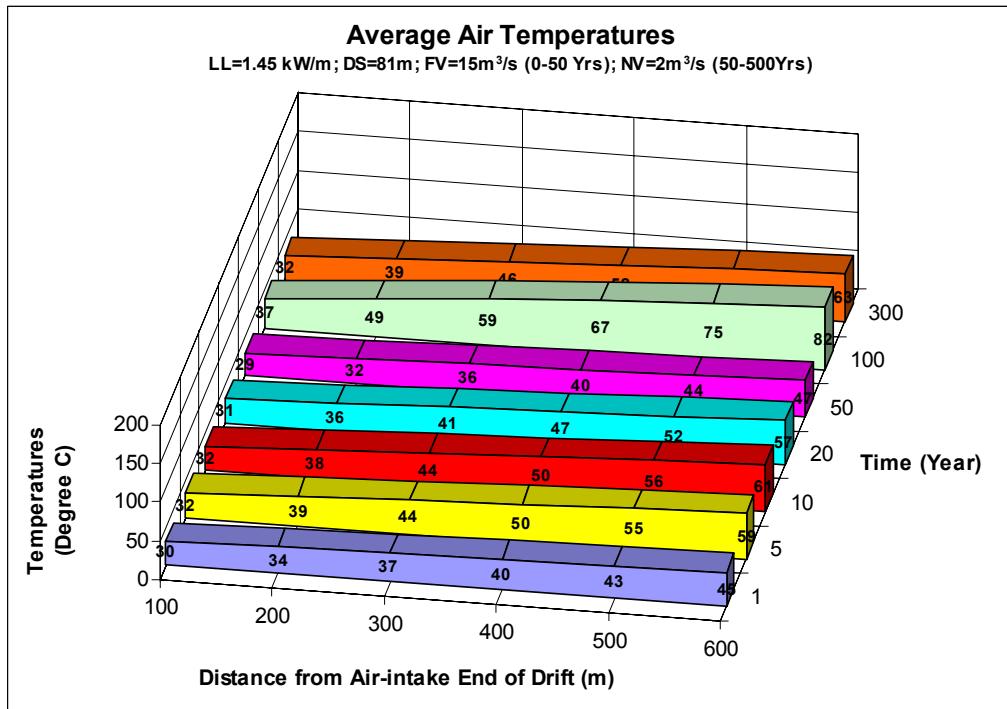
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75				
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73				
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19				
60.00	36.88%	320.81	342.85	108121.88	60.00	65.71	186.97	58962.94				
70.00	32.81%	285.42	303.12	95590.81	70.00	95.89	80.80	25481.18				
80.00	29.47%	256.40	270.91	85434.15	80.00	103.17	99.53	31387.43				
90.00	26.76%	232.84	244.62	77142.91	90.00	101.43	102.30	32260.95				
100.00	24.52%	213.32	223.08	70349.62	100.00	97.46	99.44	31360.65				
125.00	21.21%	184.50	198.91	156819.84	125.00	92.22	94.84	74770.31				
150.00	17.89%	155.68	170.09	134098.48	150.00	85.29	88.75	69972.87				
200.00	14.85%	129.19	142.43	224589.03	200.00	77.36	81.33	128236.49				
250.00	13.03%	113.33	121.26	191201.22	250.00	70.19	73.78	116332.09				
300.00	11.76%	102.34	107.84	170036.07	300.00	64.82	67.50	106440.49				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		630434.80					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		809887.96					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1305640.21					
Percentage of total heat removal in 50 years = 72%												
Percentage of total heat removal in 100 years = 62%												
Percentage of total heat removal in 300 years = 60%												

Source: DTN: MO0010MWDANS03.005



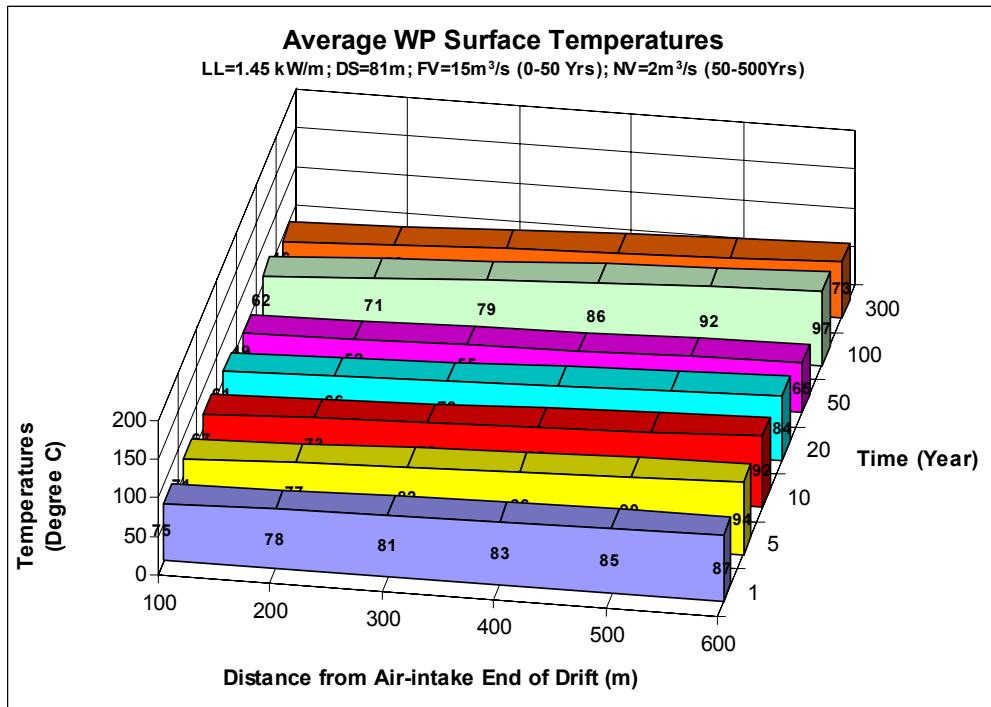
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table VIII-1, p. VIII-2.

Figure VIII-1. Average Drift Wall Temperatures for Case 07: HF5N2C8



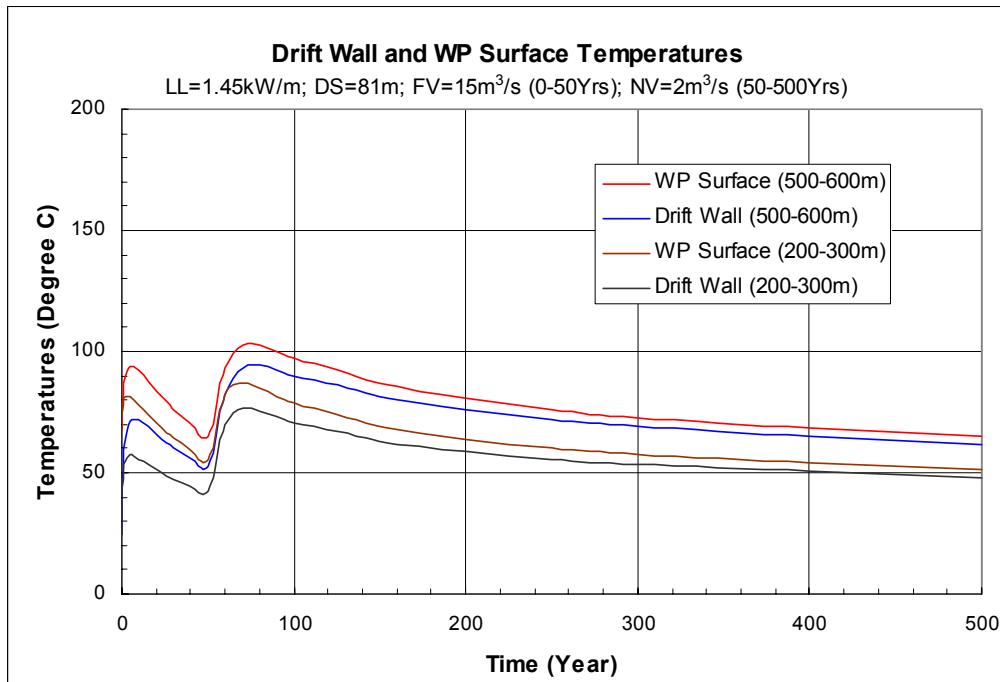
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table VIII-2, p. VIII-3.

Figure VIII-2. Average Air Temperatures for Case 07: HF5N2C8



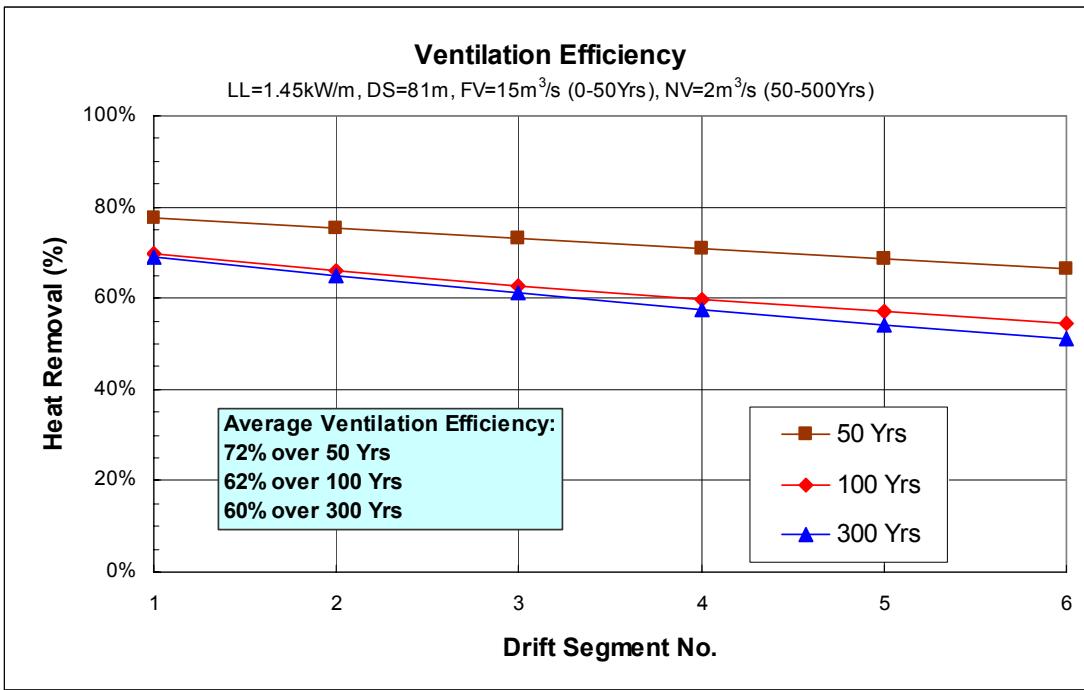
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table VIII-3, p. VIII-4.

Figure VIII-3. Average Waste Package Surface Temperatures for Case 07: HF5N2C8



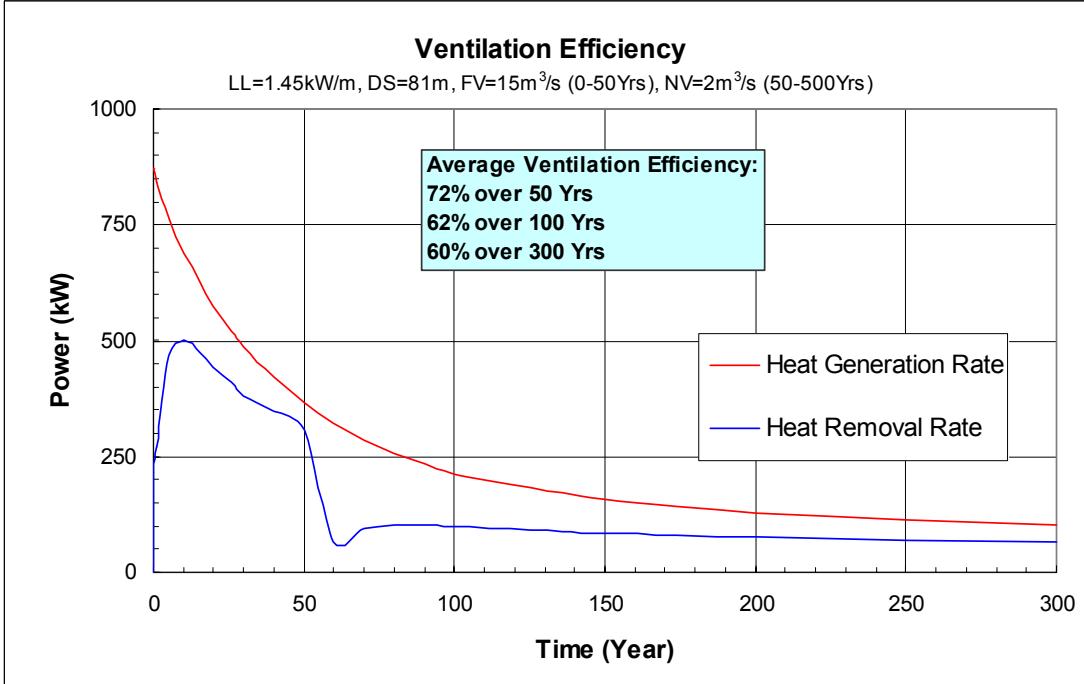
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VIII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 07: HF5N2C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VIII-5. Average Heat Removal Rates at Different Drift Segments for Case 07: HF5N2C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure VIII-6. Overall Heat Generation and Removal Rates at Different Time for Case 07: HF5N2C8

ATTACHMENT IX

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 08: HF5N3C8

ATTACHMENT IX

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 08: HF5N3C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and a natural ventilation air flow rate of 3 m³/s from 50 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table IX-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 3 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	52.38	58.24	63.32	67.80	71.84	75.52
70.00	52.57	60.53	67.43	73.43	78.70	83.35
80.00	50.58	58.56	65.79	72.31	78.16	83.42
90.00	48.79	56.40	63.41	69.84	75.73	81.12
100.00	47.24	54.47	61.17	67.38	73.13	78.43
125.00	44.85	51.64	57.99	63.94	69.49	74.66
150.00	42.35	48.52	54.38	59.94	65.18	70.13
200.00	39.84	45.34	50.63	55.72	60.59	65.23
250.00	38.29	43.22	48.01	52.66	57.13	61.45
300.00	37.19	41.72	46.14	50.44	54.60	58.63
400.00	35.58	39.70	43.73	47.69	51.54	55.30
500.00	34.39	38.06	41.71	45.31	48.85	52.33

Source: DTN: MO0010MWDANS03.005

Table IX-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 3 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	32.88	39.58	45.39	50.53	55.15	59.38
70.00	35.94	45.39	53.55	60.63	66.81	72.24
80.00	35.51	45.06	53.68	61.42	68.35	74.55
90.00	34.75	43.76	52.05	59.66	66.62	72.97
100.00	34.08	42.53	50.38	57.65	64.38	70.59
125.00	33.30	41.10	48.42	55.27	61.67	67.63
150.00	32.33	39.32	45.98	52.29	58.26	63.88
200.00	31.33	37.46	43.38	49.07	54.52	59.72
250.00	30.53	35.93	41.19	46.29	51.23	55.99
300.00	30.00	34.90	39.68	44.33	48.86	53.25
400.00	29.47	33.87	38.21	42.46	46.61	50.66
500.00	28.91	32.81	36.68	40.51	44.29	48.01

Source: DTN: MO0010MWDANS03.005

Table IX-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 3 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	65.54	70.98	75.69	79.86	83.61	87.04
70.00	64.13	71.61	78.13	83.80	88.78	93.19
80.00	61.09	68.63	75.48	81.67	87.25	92.27
90.00	58.47	65.69	72.35	78.48	84.11	89.27
100.00	56.22	63.10	69.49	75.43	80.93	86.03
125.00	52.76	59.24	65.34	71.05	76.39	81.39
150.00	49.13	55.07	60.72	66.09	71.16	75.96
200.00	45.56	50.88	56.01	60.95	65.68	70.20
250.00	43.37	48.16	52.81	57.32	61.69	65.90
300.00	41.81	46.22	50.52	54.70	58.76	62.70
400.00	39.54	43.55	47.49	51.36	55.13	58.81
500.00	37.85	41.44	45.01	48.53	52.01	55.43

Source: DTN: MO0010MWDANS03.005

Table IX-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), and 3 m³/s (50-500 Years) (Drift Spacing = 81 m)

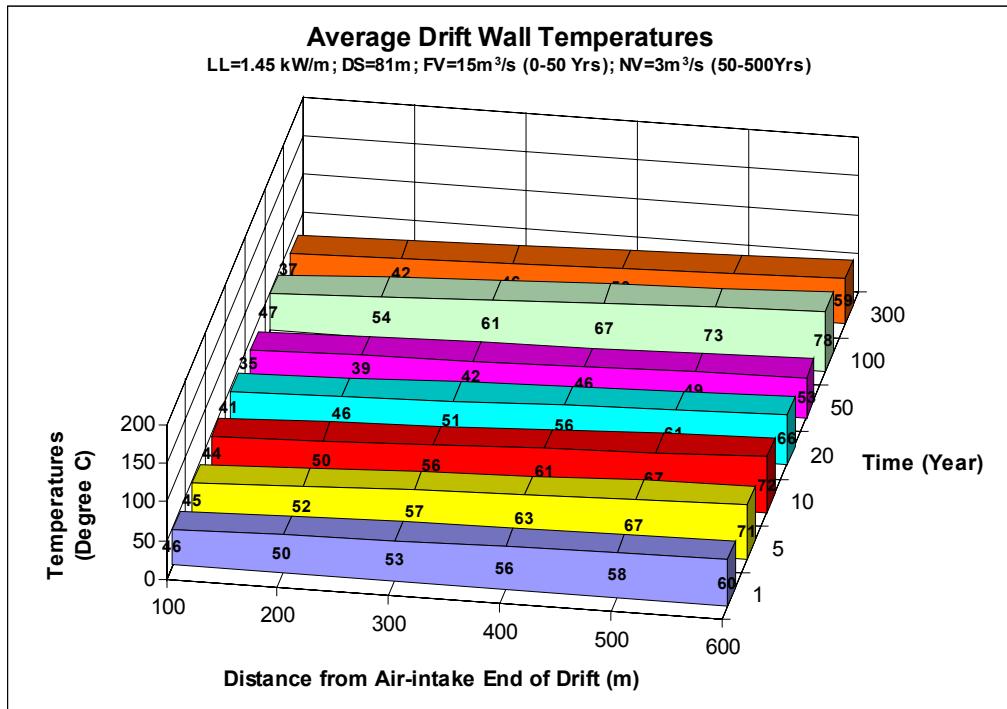
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	20.56	17.49	15.16	13.40	12.06	11.03
70.00	28.55	24.65	21.30	18.48	16.12	14.17
80.00	27.42	24.93	22.50	20.20	18.08	16.16
90.00	25.44	23.51	21.64	19.86	18.16	16.56
100.00	23.70	22.05	20.48	18.97	17.55	16.20
125.00	21.66	20.37	19.10	17.87	16.69	15.56
150.00	19.12	18.26	17.37	16.47	15.57	14.68
200.00	16.52	16.01	15.44	14.84	14.21	13.57
250.00	14.42	14.09	13.72	13.32	12.89	12.43
300.00	13.05	12.77	12.47	12.15	11.81	11.46

Source: DTN: MO0010MWDANS03.005

Table IX-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), and 3 m³/s (50-500 Years) (Drift Spacing = 81 m)

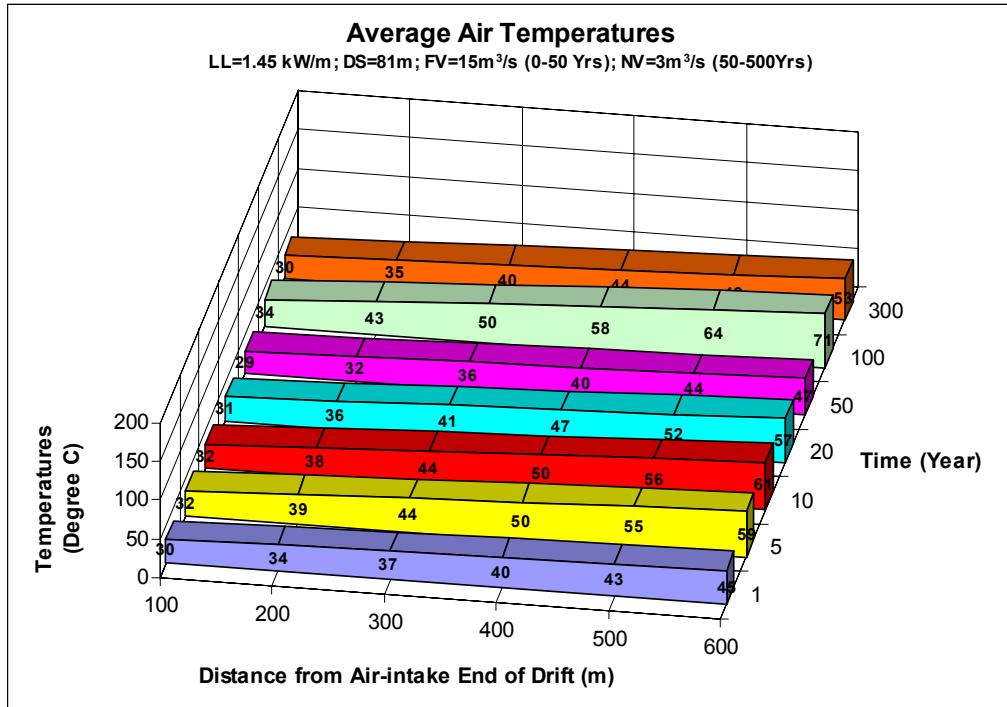
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75				
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73				
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19				
60.00	36.88%	320.81	342.85	108121.88	60.00	89.70	198.96	62745.18				
70.00	32.81%	285.42	303.12	95590.81	70.00	123.26	106.48	33579.91				
80.00	29.47%	256.40	270.91	85434.15	80.00	129.28	126.27	39821.71				
90.00	26.76%	232.84	244.62	77142.91	90.00	125.18	127.23	40123.27				
100.00	24.52%	213.32	223.08	70349.62	100.00	118.95	122.06	38493.67				
125.00	21.21%	184.50	198.91	156819.84	125.00	111.24	115.10	90742.70				
150.00	17.89%	155.68	170.09	134098.48	150.00	101.45	106.35	83845.34				
200.00	14.85%	129.19	142.43	224589.03	200.00	90.59	96.02	151407.87				
250.00	13.03%	113.33	121.26	191201.22	250.00	80.88	85.73	135185.49				
300.00	11.76%	102.34	107.84	170036.07	300.00	73.72	77.30	121880.08				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		630434.80					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		845198.54					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1428260.01					
Percentage of total heat removal in 50 years = 72%												
Percentage of total heat removal in 100 years = 64%												
Percentage of total heat removal in 300 years = 65%												

Source: DTN: MO0010MWDANS03.005



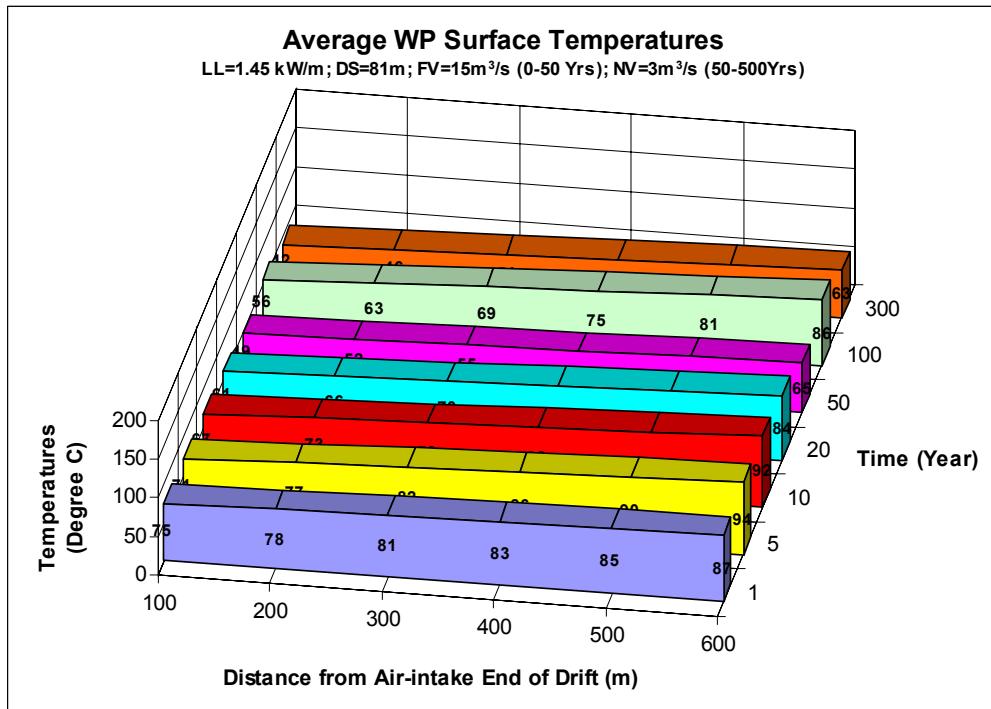
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table IX-1, p. IX-2.

Figure IX-1. Average Drift Wall Temperatures for Case 08: HF5N3C8



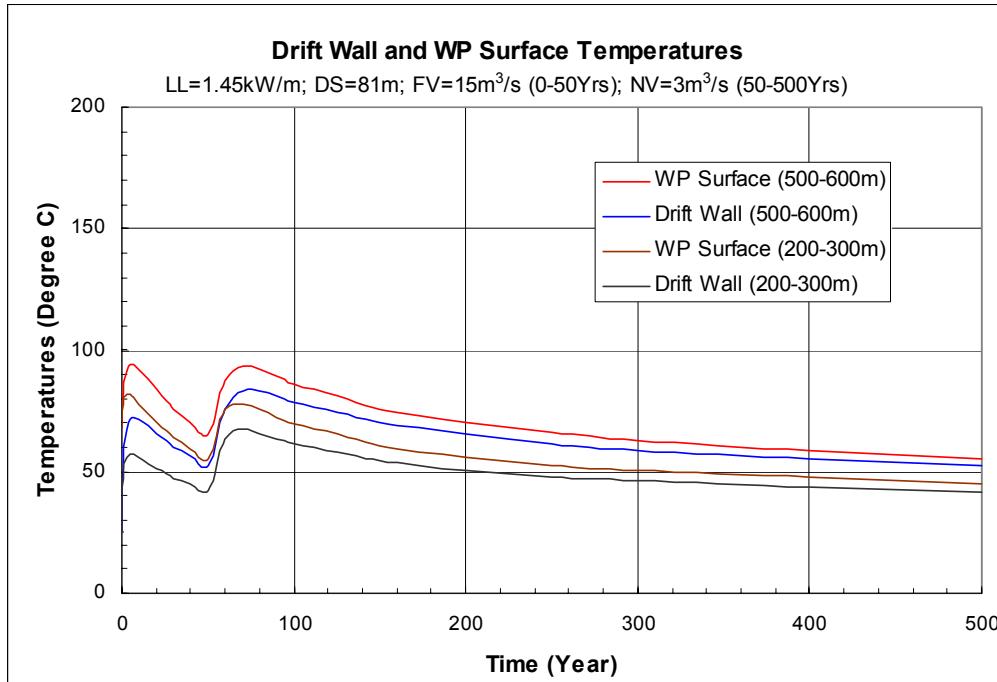
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table IX-2, p. IX-3.

Figure IX-2. Average Air Temperatures for Case 08: HF5N3C8



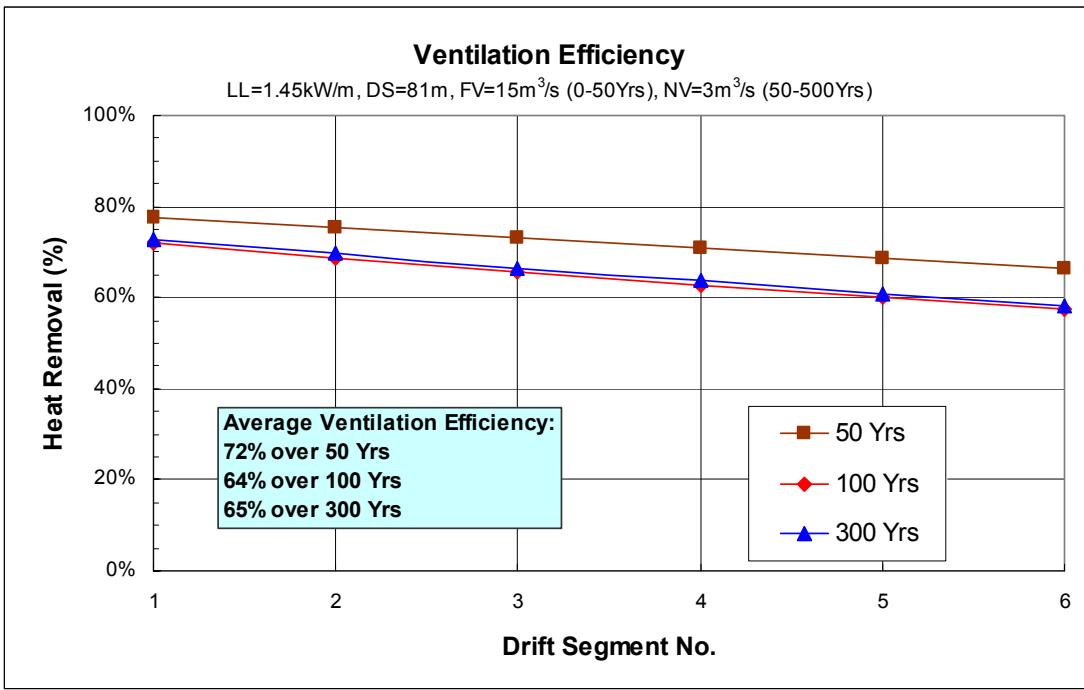
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table IX-3, p. IX-4.

Figure IX-3. Average Waste Package Surface Temperatures for Case 08: HF5N3C8



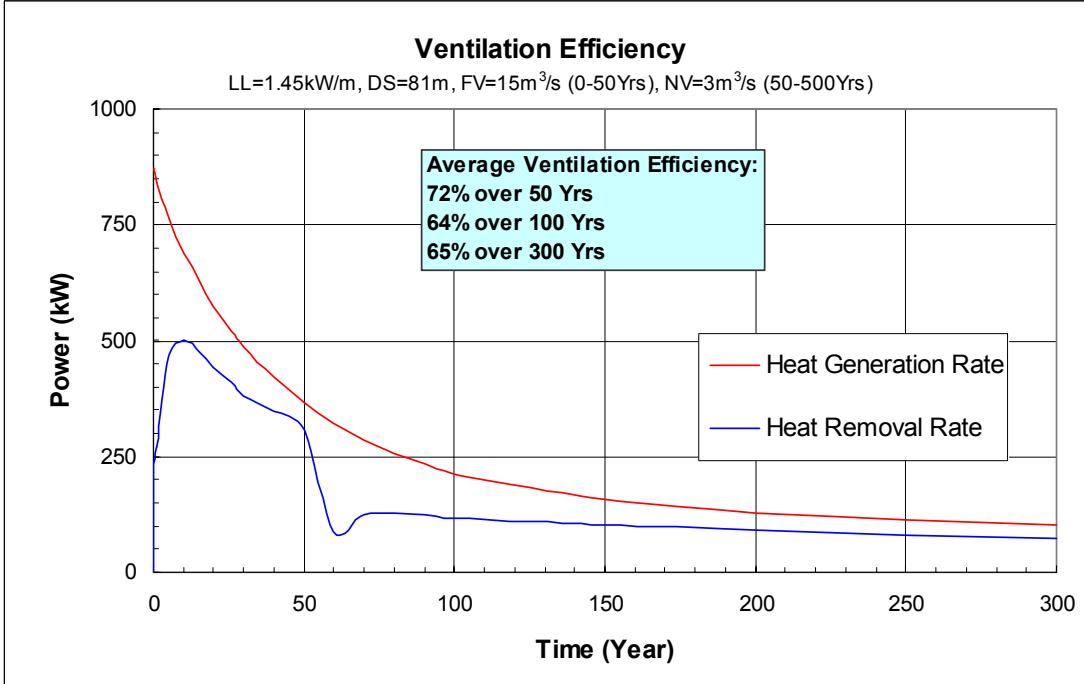
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure IX-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 08: HF5N3C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure IX-5. Average Heat Removal Rates at Different Drift Segments for Case 08: HF5N3C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure IX-6. Overall Heat Generation and Removal Rates at Different Time for Case 08: HF5N3C8

ATTACHMENT X

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 09: HF5N4C8

ATTACHMENT X

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 09: HF5N4C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and a natural ventilation air flow rate of 4 m³/s from 50 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table X-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 4 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	48.33	53.71	58.51	62.84	66.81	70.49
70.00	47.79	54.74	60.95	66.52	71.53	76.05
80.00	45.99	52.79	59.13	64.99	70.40	75.38
90.00	44.43	50.84	56.89	62.58	67.93	72.92
100.00	43.09	49.14	54.87	60.30	65.44	70.28
125.00	41.04	46.65	52.02	57.15	62.04	66.70
150.00	38.93	43.97	48.86	53.58	58.13	62.50
200.00	36.82	41.27	45.61	49.86	54.01	58.04
250.00	35.54	39.48	43.36	47.18	50.94	54.61
300.00	34.63	38.23	41.78	45.27	48.71	52.09
400.00	33.32	36.55	39.76	42.94	46.08	49.20
500.00	32.35	35.21	38.08	40.95	43.80	46.64

Source: DTN: MO0010MWDANS03.005

Table X-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 4 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	31.80	37.78	43.10	47.93	52.36	56.48
70.00	33.90	41.82	48.89	55.20	60.86	65.96
80.00	33.39	41.24	48.51	55.22	61.40	67.06
90.00	32.74	40.07	46.98	53.48	59.57	65.26
100.00	32.18	39.01	45.50	51.65	57.46	62.95
125.00	31.53	37.80	43.80	49.54	55.01	60.22
150.00	30.73	36.30	41.71	46.93	51.97	56.81
200.00	29.92	34.76	39.51	44.16	48.70	53.11
250.00	29.27	33.50	37.68	41.80	45.85	49.83
300.00	28.85	32.66	36.43	40.15	43.82	47.44
400.00	28.42	31.83	35.23	38.59	41.93	45.23
500.00	27.98	30.98	33.99	37.00	40.00	42.98

Source: DTN: MO0010MWDANS03.005

Table X-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 4 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	61.50	66.49	70.94	74.96	78.66	82.09
70.00	59.44	65.97	71.83	77.09	81.82	86.10
80.00	56.59	63.00	69.00	74.56	79.70	84.44
90.00	54.18	60.25	65.99	71.41	76.51	81.28
100.00	52.13	57.87	63.33	68.51	73.43	78.07
125.00	48.97	54.33	59.48	64.40	69.10	73.58
150.00	45.72	50.57	55.28	59.84	64.23	68.47
200.00	42.55	46.84	51.05	55.17	59.19	63.11
250.00	40.62	44.43	48.20	51.91	55.56	59.14
300.00	39.25	42.74	46.19	49.59	52.94	56.24
400.00	37.26	40.41	43.54	46.65	49.72	52.77
500.00	35.80	38.59	41.40	44.20	47.00	49.78

Source: DTN: MO0010MWDANS03.005

Table X-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), and 4 m³/s (50-500 Years) (Drift Spacing = 81 m)

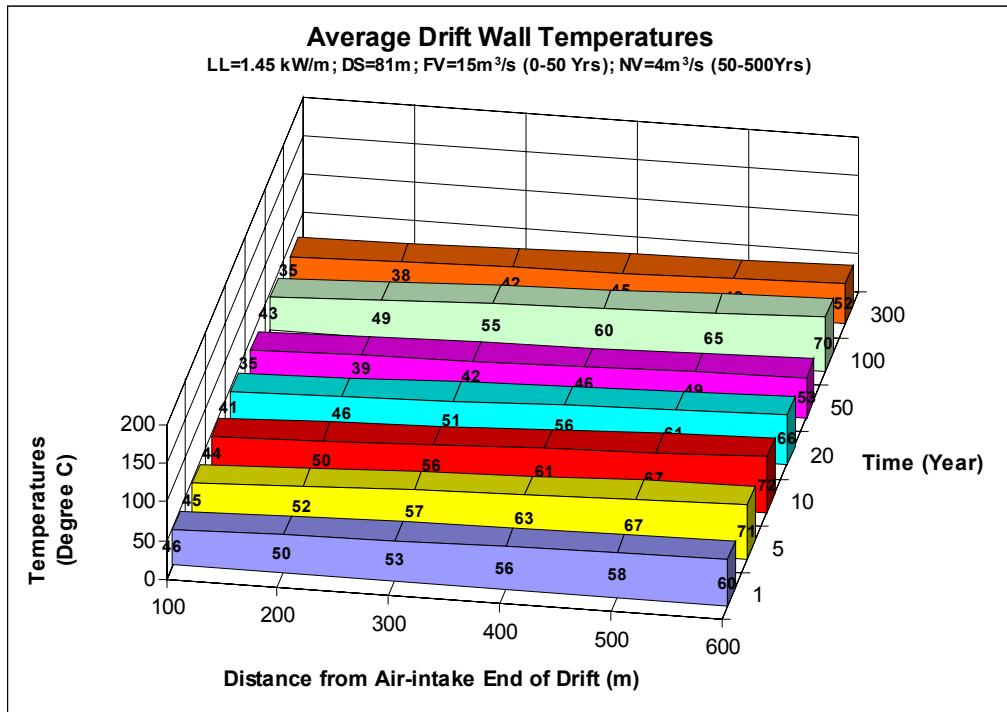
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	23.92	21.00	18.73	16.96	15.58	14.49
70.00	31.28	27.87	24.84	22.19	19.91	17.95
80.00	29.52	27.57	25.58	23.61	21.71	19.92
90.00	27.23	25.75	24.30	22.84	21.41	20.02
100.00	25.26	24.02	22.80	21.61	20.45	19.31
125.00	22.97	22.04	21.10	20.17	19.24	18.31
150.00	20.14	19.59	19.00	18.37	17.71	17.04
200.00	17.29	17.03	16.71	16.35	15.94	15.51
250.00	15.01	14.87	14.70	14.49	14.25	13.98
300.00	13.53	13.40	13.25	13.09	12.91	12.71

Source: DTN: MO0010MWDANS03.005

Table X-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), and 4 m³/s (50-500 Years) (Drift Spacing = 81 m)

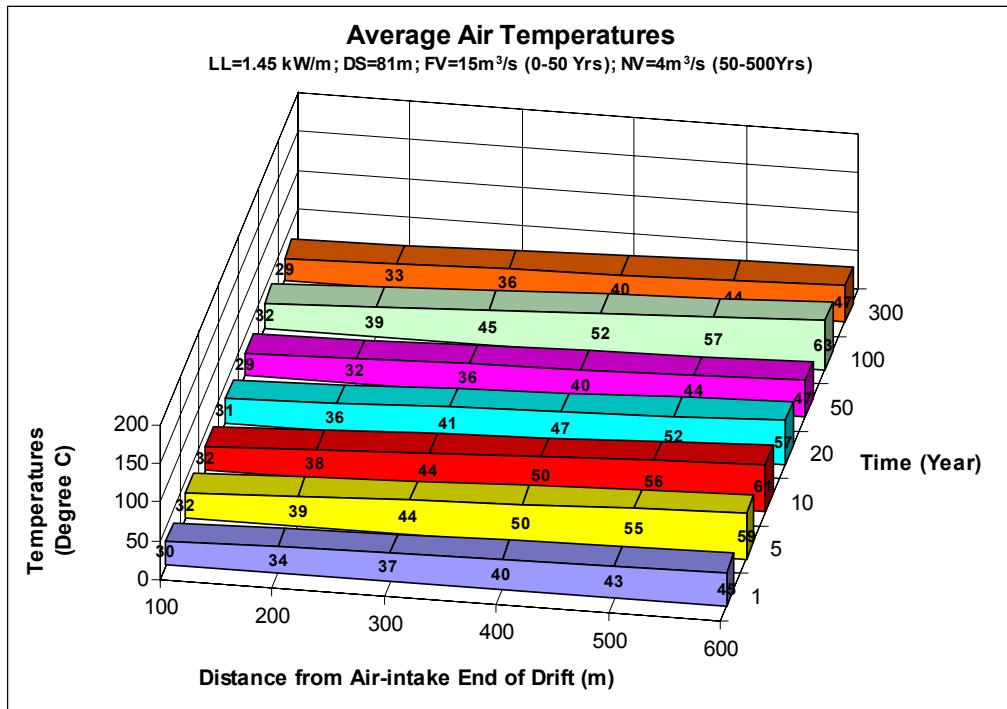
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75				
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73				
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19				
60.00	36.88%	320.81	342.85	108121.88	60.00	110.69	209.46	66054.31				
70.00	32.81%	285.42	303.12	95590.81	70.00	144.03	127.36	40164.07				
80.00	29.47%	256.40	270.91	85434.15	80.00	147.90	145.97	46032.57				
90.00	26.76%	232.84	244.62	77142.91	90.00	141.56	144.73	45641.95				
100.00	24.52%	213.32	223.08	70349.62	100.00	133.45	137.50	43363.13				
125.00	21.21%	184.50	198.91	156819.84	125.00	123.82	128.64	101416.93				
150.00	17.89%	155.68	170.09	134098.48	150.00	111.86	117.84	92905.17				
200.00	14.85%	129.19	142.43	224589.03	200.00	98.84	105.35	166112.53				
250.00	13.03%	113.33	121.26	191201.22	250.00	87.31	93.07	146754.92				
300.00	11.76%	102.34	107.84	170036.07	300.00	78.90	83.10	131038.89				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		630434.80					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		871690.83					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1509919.28					
Percentage of total heat removal in 50 years = 72%												
Percentage of total heat removal in 100 years = 66%												
Percentage of total heat removal in 300 years = 69%												

Source: DTN: MO0010MWDANS03.005



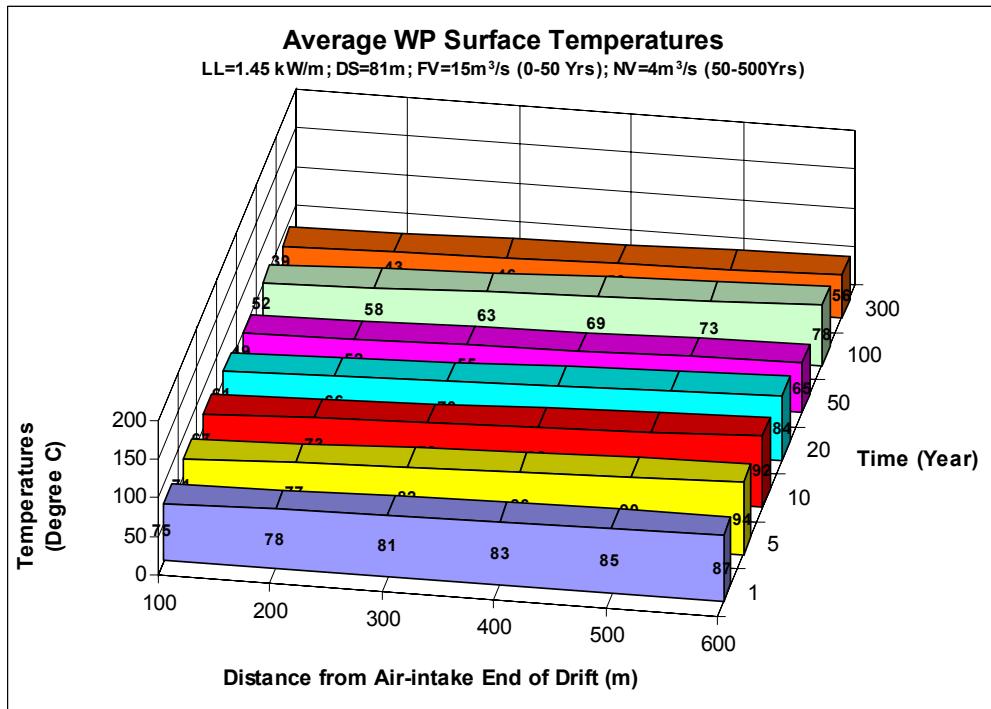
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table X-1, p. X-2.

Figure X-1. Average Drift Wall Temperatures for Case 09: HF5N4C8



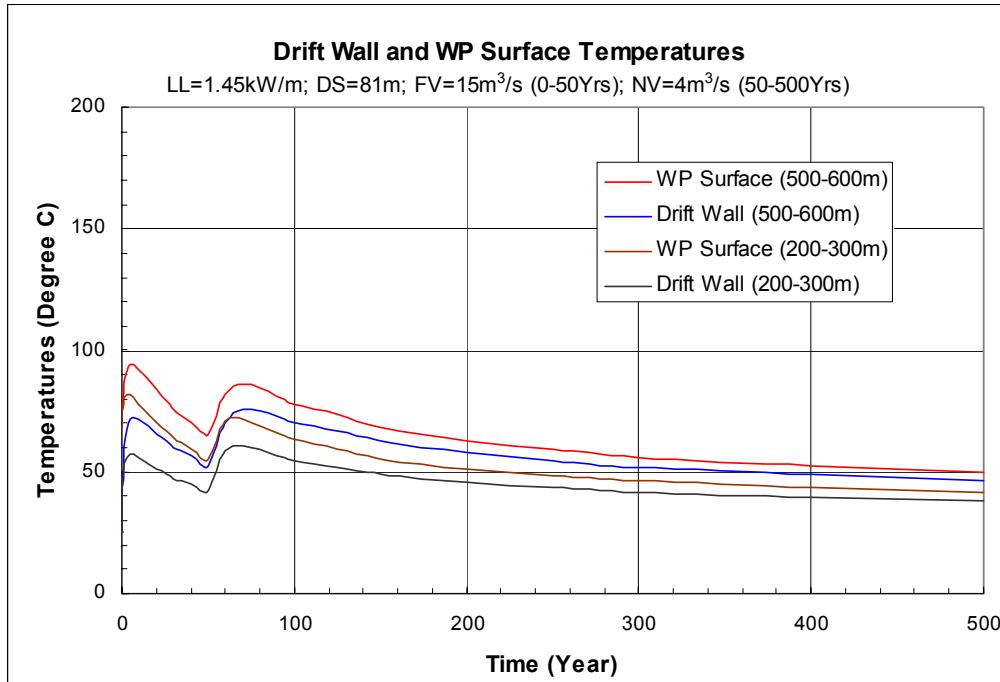
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table X-2, p. X-3.

Figure X-2. Average Air Temperatures for Case 09: HF5N4C8



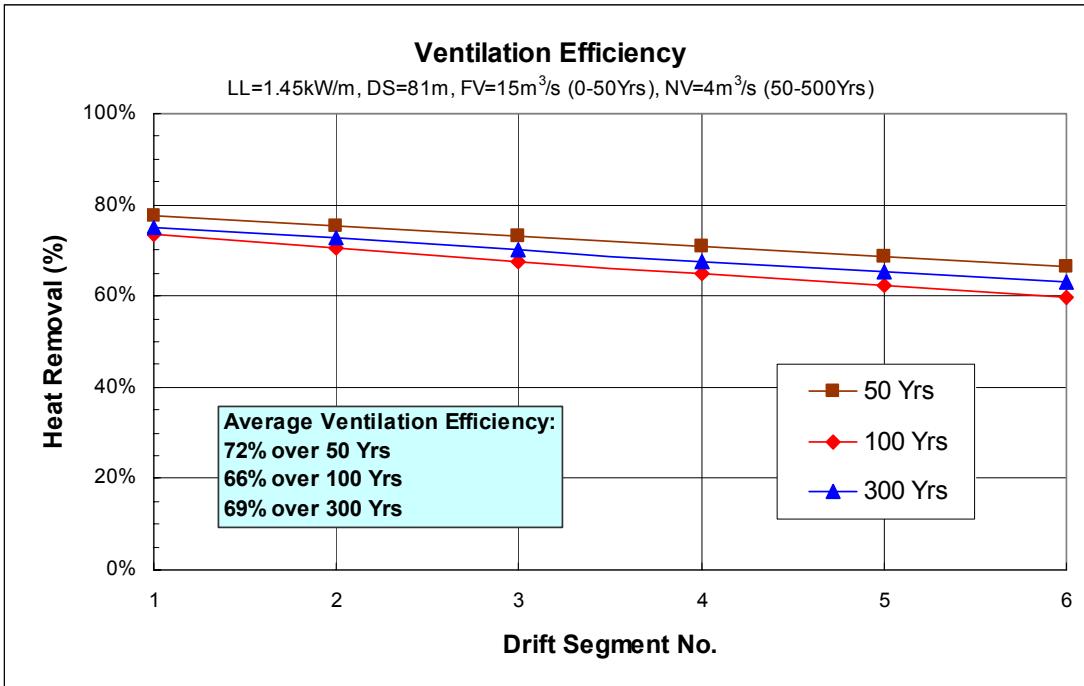
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table X-3, p. X-4.

Figure X-3. Average Waste Package Surface Temperatures for Case 09: HF5N4C8



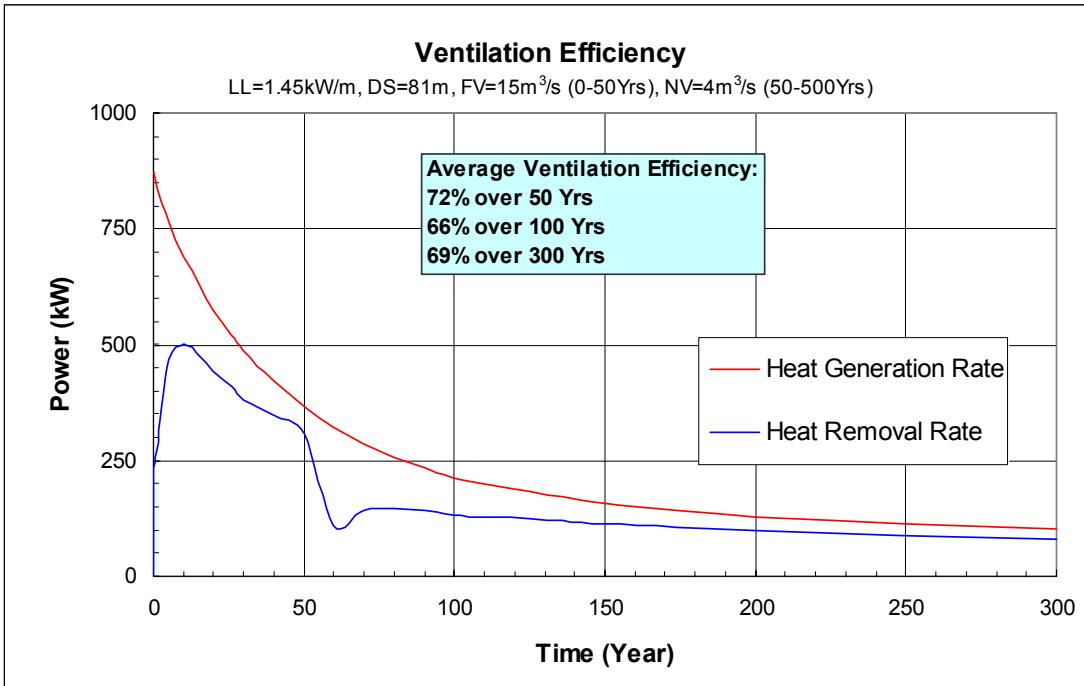
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure X-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 09: HF5N4C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure X-5. Average Heat Removal Rates at Different Drift Segments for Case 09: HF5N4C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure X-6. Overall Heat Generation and Removal Rates at Different Time for Case 09: HF5N4C8

ATTACHMENT XI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 10: HF5N5C8

ATTACHMENT XI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 10: HF5N5C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and a natural ventilation air flow rate of 5 m³/s from 50 to 500 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XI-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 5 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	45.39	50.37	54.90	59.06	62.94	66.58
70.00	44.51	50.65	56.26	61.39	66.10	70.44
80.00	42.88	48.79	54.39	59.66	64.62	69.27
90.00	41.50	47.02	52.31	57.37	62.19	66.78
100.00	40.33	45.50	50.48	55.27	59.87	64.26
125.00	38.53	43.30	47.92	52.40	56.73	60.90
150.00	36.69	40.95	45.12	49.20	53.18	57.06
200.00	34.88	38.59	42.26	45.90	49.48	53.00
250.00	33.78	37.05	40.30	43.53	46.73	49.91
300.00	33.01	35.97	38.93	41.86	44.77	47.66
400.00	31.89	34.55	37.20	39.85	42.49	45.12
500.00	31.08	33.42	35.77	38.13	40.51	42.89

Source: DTN: MO0010MWDANS03.005

Table XI-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 5 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	31.03	36.45	41.39	45.96	50.21	54.22
70.00	32.49	39.32	45.54	51.22	56.43	61.21
80.00	31.99	38.63	44.90	50.81	56.34	61.51
90.00	31.42	37.58	43.49	49.13	54.51	59.62
100.00	30.94	36.66	42.18	47.48	52.56	57.44
125.00	30.38	35.61	40.68	45.60	50.35	54.93
150.00	29.70	34.32	38.86	43.30	47.63	51.85
200.00	29.02	33.01	36.97	40.89	44.75	48.55
250.00	28.47	31.94	35.40	38.84	42.26	45.65
300.00	28.12	31.24	34.34	37.43	40.50	43.56
400.00	27.77	30.55	33.33	36.11	38.88	41.64
500.00	27.41	29.84	32.29	34.76	37.24	39.72

Source: DTN: MO0010MWDANS03.005

Table XI-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), and 5 m³/s (50-500 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	58.51	63.14	67.34	71.21	74.83	78.22
70.00	56.18	61.94	67.23	72.07	76.51	80.62
80.00	53.49	59.06	64.35	69.34	74.06	78.48
90.00	51.25	56.48	61.49	66.31	70.90	75.28
100.00	49.35	54.27	59.01	63.58	67.96	72.17
125.00	46.44	51.00	55.42	59.71	63.87	67.89
150.00	43.46	47.55	51.56	55.50	59.34	63.09
200.00	40.57	44.16	47.71	51.23	54.71	58.12
250.00	38.82	41.98	45.14	48.28	51.39	54.48
300.00	37.59	40.47	43.34	46.19	49.03	51.84
400.00	35.80	38.39	40.98	43.56	46.15	48.72
500.00	34.49	36.78	39.08	41.39	43.72	46.05

Source: DTN: MO0010MWDANS03.005

Table XI-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), and 5 m³/s (50-500 Years) (Drift Spacing = 81 m)

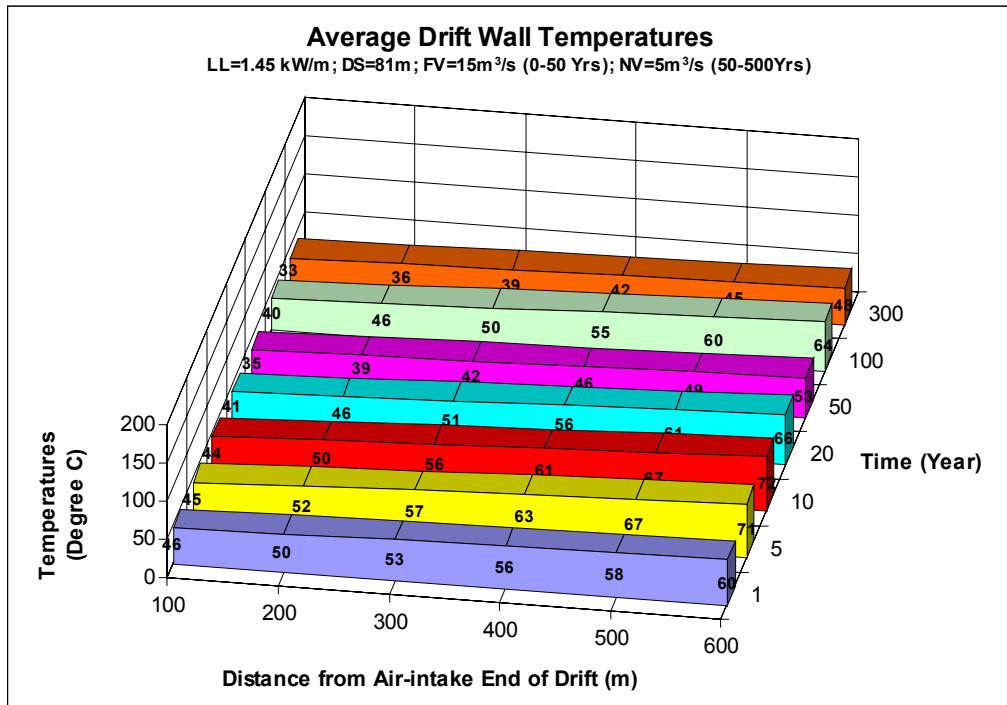
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	26.73	24.05	21.92	20.23	18.88	17.79
70.00	33.22	30.27	27.59	25.19	23.08	21.22
80.00	30.98	29.45	27.83	26.16	24.52	22.93
90.00	28.46	27.33	26.18	25.01	23.84	22.66
100.00	26.34	25.38	24.44	23.50	22.56	21.62
125.00	23.86	23.19	22.49	21.78	21.06	20.32
150.00	20.84	20.50	20.11	19.68	19.22	18.72
200.00	17.80	17.71	17.56	17.37	17.13	16.85
250.00	15.39	15.38	15.34	15.27	15.16	15.02
300.00	13.84	13.80	13.76	13.70	13.63	13.54

Source: DTN: MO0010MWDANS03.005

Table XI-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), and 5 m³/s (50-500 Years) (Drift Spacing = 81 m)

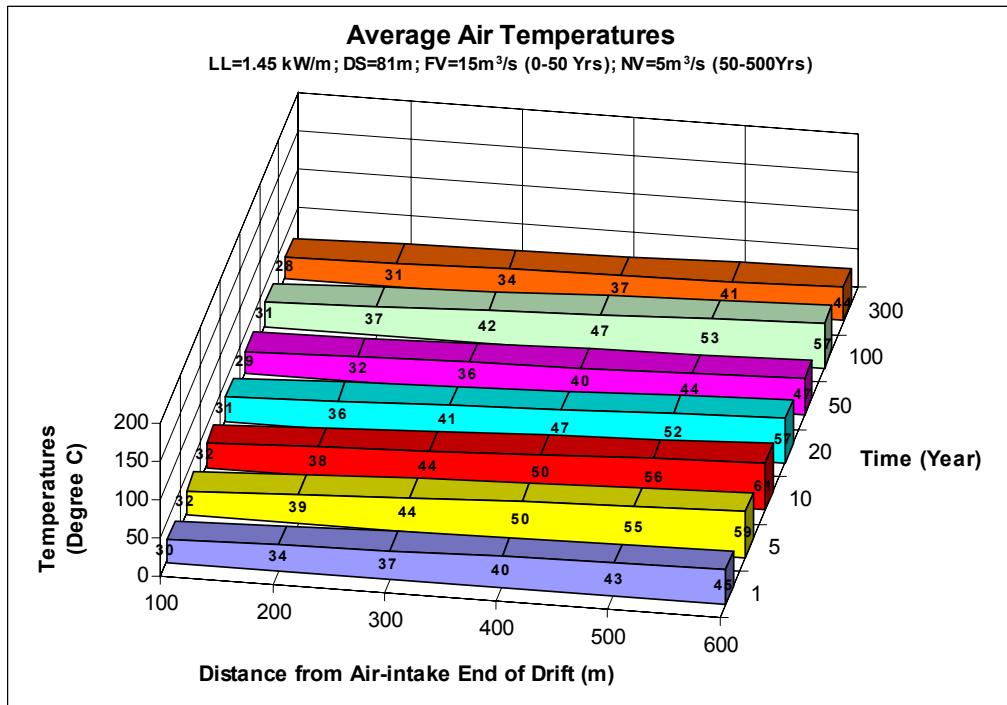
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75				
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73				
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19				
60.00	36.88%	320.81	342.85	108121.88	60.00	129.58	218.90	69033.77				
70.00	32.81%	285.42	303.12	95590.81	70.00	160.57	145.08	45751.71				
80.00	29.47%	256.40	270.91	85434.15	80.00	161.87	161.22	50843.16				
90.00	26.76%	232.84	244.62	77142.91	90.00	153.49	157.68	49725.69				
100.00	24.52%	213.32	223.08	70349.62	100.00	143.84	148.67	46883.25				
125.00	21.21%	184.50	198.91	156819.84	125.00	132.71	138.28	109016.50				
150.00	17.89%	155.68	170.09	134098.48	150.00	119.07	125.89	99250.40				
200.00	14.85%	129.19	142.43	224589.03	200.00	104.43	111.75	176206.15				
250.00	13.03%	113.33	121.26	191201.22	250.00	91.57	98.00	154523.20				
300.00	11.76%	102.34	107.84	170036.07	300.00	82.28	86.93	137064.01				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		630434.80					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		892672.39					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1568732.66					
Percentage of total heat removal in 50 years = 72%												
Percentage of total heat removal in 100 years = 68%												
Percentage of total heat removal in 300 years = 72%												

Source: DTN: MO0010MWDANS03.005



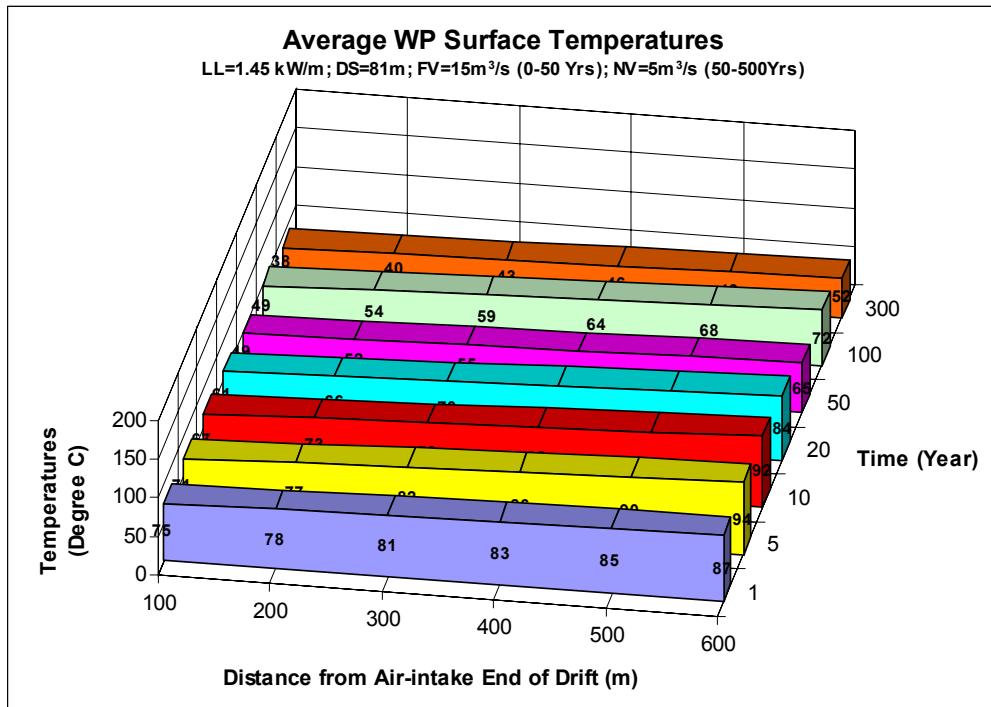
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XI-1, p. XI-2.

Figure XI-1. Average Drift Wall Temperatures for Case 10: HF5N5C8



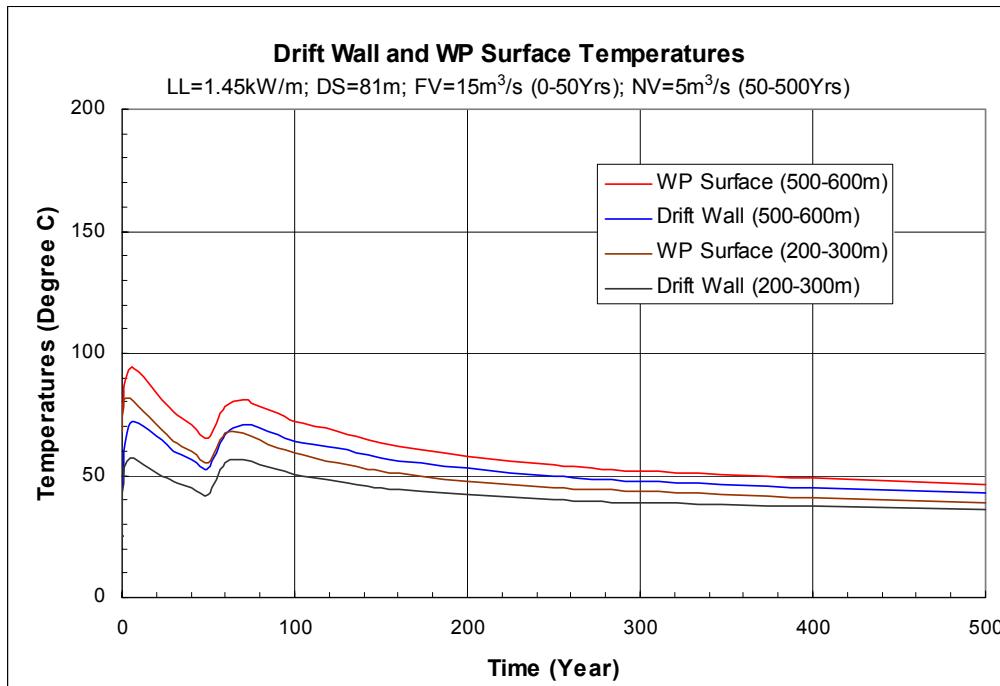
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XI-2, p. XI-3.

Figure XI-2. Average Air Temperatures for Case 10: HF5N5C8



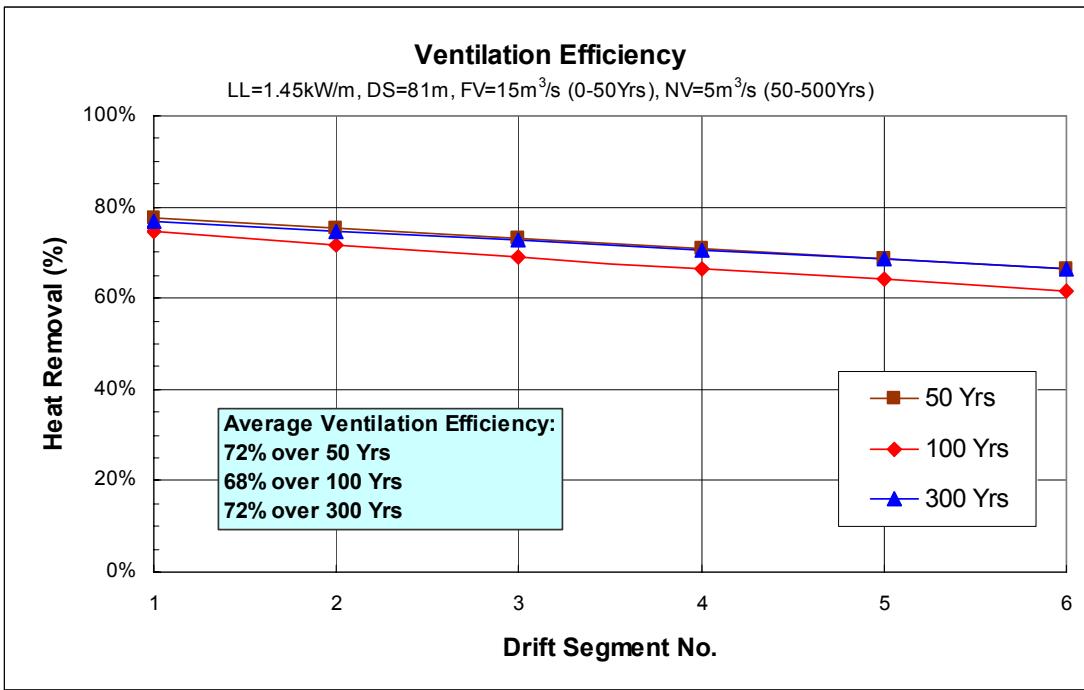
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XI-3, p. XI-4.

Figure XI-3. Average Waste Package Surface Temperatures for Case 10: HF5N5C8



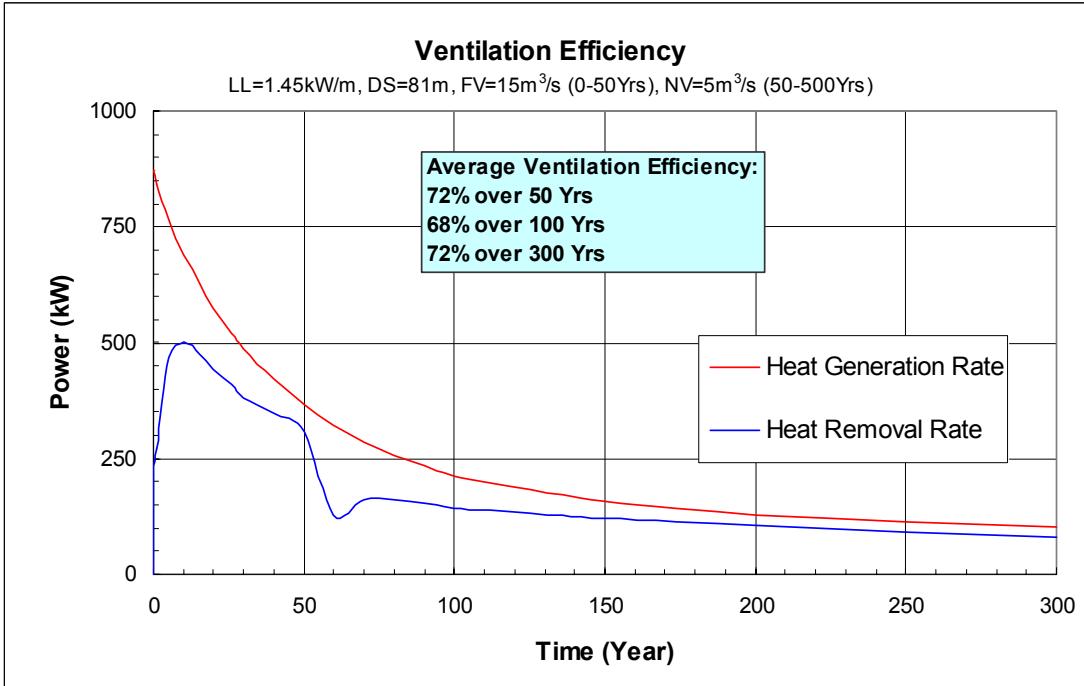
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XI-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 10: HF5N5C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XI-5. Average Heat Removal Rates at Different Drift Segments for Case 10: HF5N5C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XI-6. Overall Heat Generation and Removal Rates at Different Time for Case 10: HF5N5C8

ATTACHMENT XII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 11: HF7N1C8

ATTACHMENT XII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 11: HF7N1C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 75 years and a natural ventilation air flow rate of 1 m³/s from 75 to 300 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 1 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	34.02	37.16	40.30	43.44	46.57	49.69
70.00	33.06	35.87	38.68	41.49	44.30	47.11
75.00	32.63	35.24	37.84	40.43	43.01	45.58
80.00	55.52	61.20	65.54	69.08	72.09	74.75
90.00	63.82	72.36	78.81	83.77	87.69	90.88
100.00	62.91	72.83	80.51	86.50	91.25	95.06
125.00	60.74	71.12	79.44	86.13	91.51	95.88
150.00	57.45	67.61	75.99	82.86	88.51	93.17
200.00	54.03	63.87	72.16	79.13	84.97	89.87
250.00	51.81	61.21	69.29	76.20	82.10	87.12
300.00	50.14	59.20	67.08	73.91	79.80	84.88

Source: DTN: MO0010MWDANS03.005

Table XII-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 1 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	28.28	31.57	34.85	38.14	41.42	44.70
70.00	27.92	30.84	33.77	36.70	39.63	42.56
75.00	27.69	30.37	33.05	35.72	38.39	41.06
80.00	34.87	42.09	47.56	51.91	55.52	58.66
90.00	42.00	54.42	63.58	70.46	75.75	79.94
100.00	43.56	57.80	68.70	77.09	83.60	88.71
125.00	42.76	56.98	68.31	77.33	84.51	90.25
150.00	41.39	54.94	66.06	75.17	82.61	88.70
200.00	39.75	52.28	62.86	71.74	79.16	85.36
250.00	38.37	49.98	60.00	68.59	75.92	82.15
300.00	37.42	48.35	57.90	66.21	73.40	79.59

Source: DTN: MO0010MWDANS03.005

Table XII-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 1 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	46.17	49.10	52.03	54.96	57.90	60.83
70.00	43.97	46.61	49.25	51.90	54.55	57.20
75.00	42.99	45.44	47.89	50.33	52.77	55.20
80.00	66.90	72.22	76.29	79.59	82.41	84.89
90.00	73.32	81.48	87.65	92.39	96.14	99.19
100.00	71.64	81.15	88.53	94.30	98.86	102.53
125.00	68.37	78.35	86.39	92.85	98.06	102.29
150.00	64.01	73.85	81.97	88.65	94.15	98.68
200.00	59.58	69.14	77.22	84.02	89.73	94.51
250.00	56.74	65.90	73.79	80.55	86.33	91.25
300.00	54.63	63.47	71.18	77.87	83.66	88.64

Source: DTN: MO0010MWDANS03.005

Table XII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-75 Years), and 1 m³/s (75-300 Years) (Drift Spacing = 81 m)

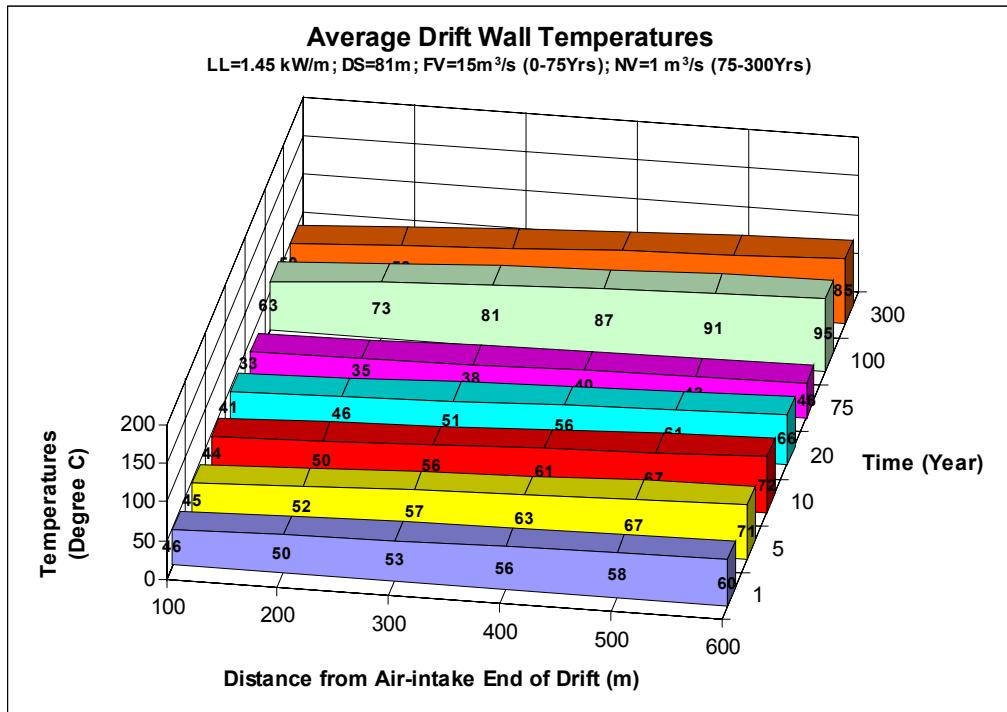
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	45.41	45.44	45.46	45.45	45.40	45.32
70.00	40.40	40.45	40.49	40.51	40.52	40.51
75.00	37.16	37.11	37.05	37.01	36.96	36.91
80.00	8.08	5.90	4.48	3.55	2.96	2.57
90.00	13.91	10.16	7.49	5.63	4.33	3.43
100.00	15.18	11.64	8.92	6.86	5.32	4.18
125.00	14.53	11.63	9.27	7.37	5.87	4.70
150.00	13.41	11.08	9.10	7.45	6.09	4.97
200.00	12.06	10.25	8.65	7.26	6.07	5.07
250.00	10.94	9.50	8.20	7.03	5.99	5.09
300.00	10.16	8.94	7.82	6.80	5.88	5.07

Source: DTN: MO0010MWDANS03.005

Table XII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-75 Years), and 1 m³/s (75-300 Years) (Drift Spacing = 81 m)

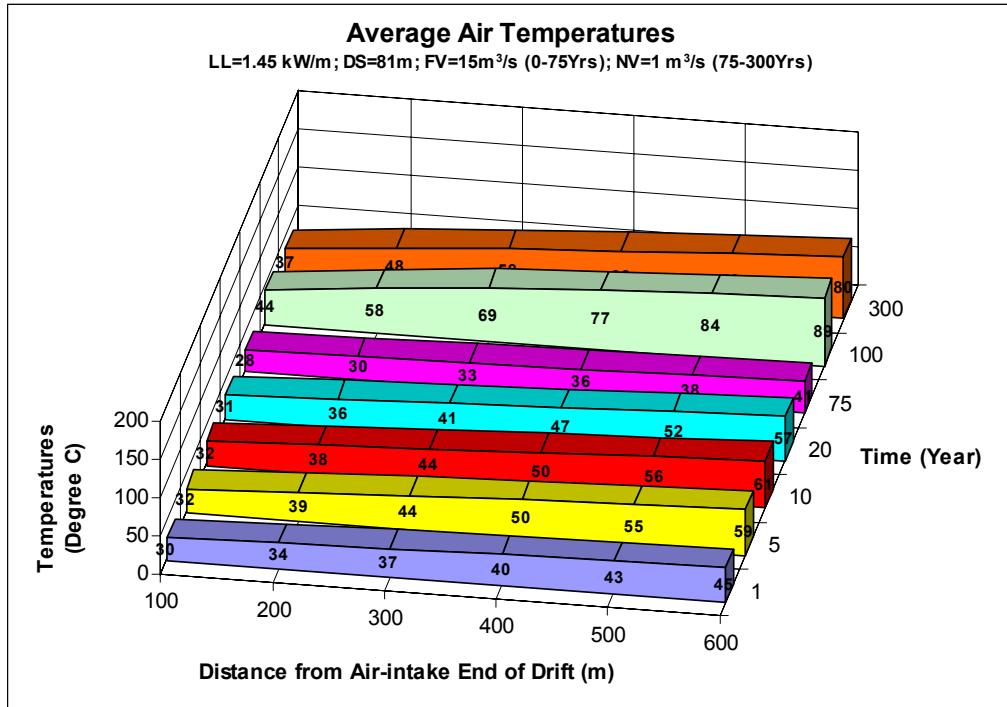
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07			
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31			
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37			
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24			
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48			
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32			
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75			
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73			
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19			
60.00	36.88%	320.81	342.85	108121.88	60.00	272.48	290.35	91565.99			
70.00	32.81%	285.42	303.12	95590.81	70.00	242.88	257.68	81262.48			
75.00	31.03%	269.93	277.67	43783.66	75.00	222.20	232.54	36667.50			
80.00	29.47%	256.40	270.91	85434.15	80.00	27.54	135.21	42639.64			
90.00	26.76%	232.84	244.62	77142.91	90.00	44.94	36.24	11427.48			
100.00	24.52%	213.32	223.08	70349.62	100.00	52.12	48.53	15303.33			
125.00	21.21%	184.50	198.91	156819.84	125.00	53.38	52.75	41585.56			
150.00	17.89%	155.68	170.09	134098.48	150.00	52.10	52.74	41580.48			
200.00	14.85%	129.19	142.43	224589.03	200.00	49.37	50.74	80004.55			
250.00	13.03%	113.33	121.26	191201.22	250.00	46.75	48.06	75780.83			
300.00	11.76%	102.34	107.84	170036.07	300.00	44.66	45.70	72061.37			
Total heat generated in 75 years (GJ)				1123999.12	Total heat removed in 75 years (GJ)			839930.78			
Total heat generated in 100 years (GJ)				1356925.79	Total heat removed in 100 years (GJ)			909301.24			
Total heat generated in 300 years (GJ)				2233670.43	Total heat removed in 300 years (GJ)			1220314.01			
Percentage of total heat removal in 75 years = 75%											
Percentage of total heat removal in 100 years = 67%											
Percentage of total heat removal in 300 years = 55%											

Source: DTN: MO0010MWDANS03.005



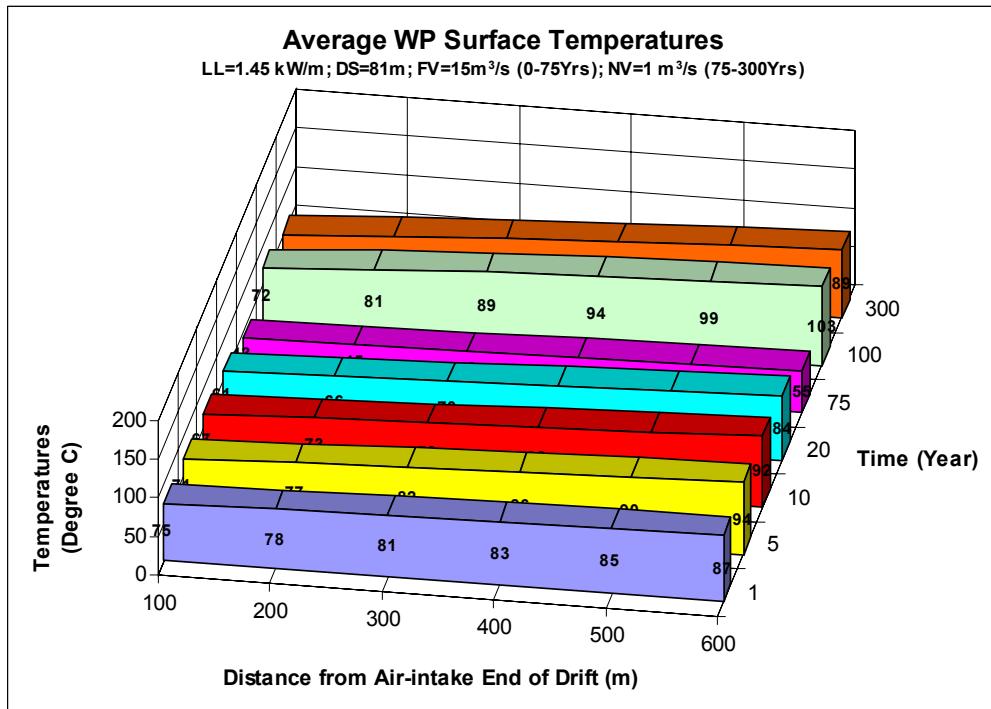
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table XII-1, p. XII-2.

Figure XII-1. Average Drift Wall Temperatures for Case 11: HF7N1C8



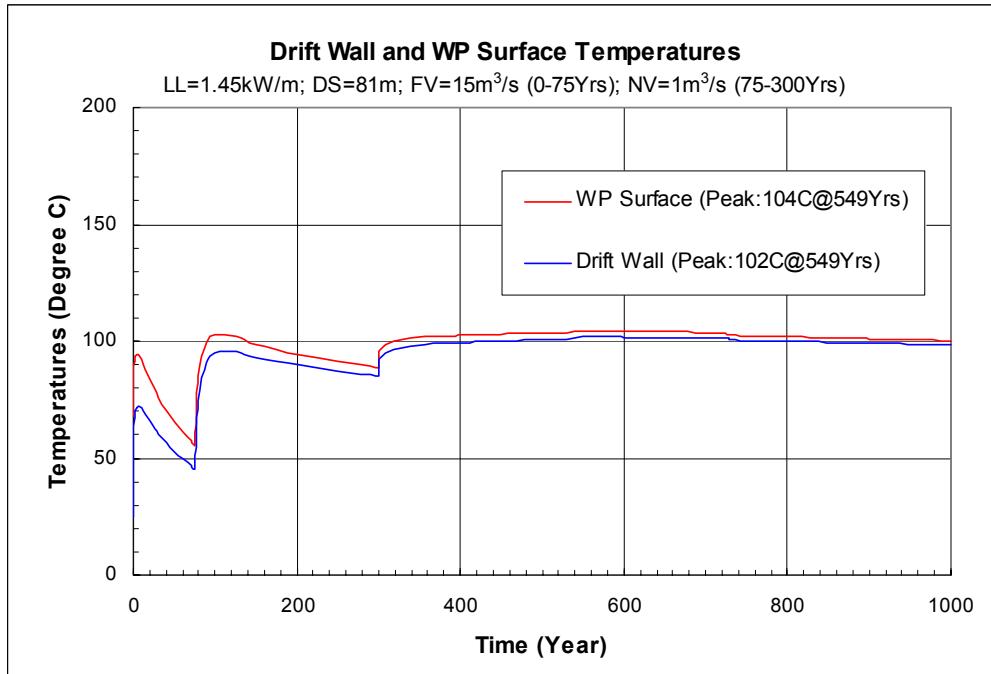
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table XII-2, p. XII-3.

Figure XII-2. Average Air Temperatures for Case 11: HF7N1C8



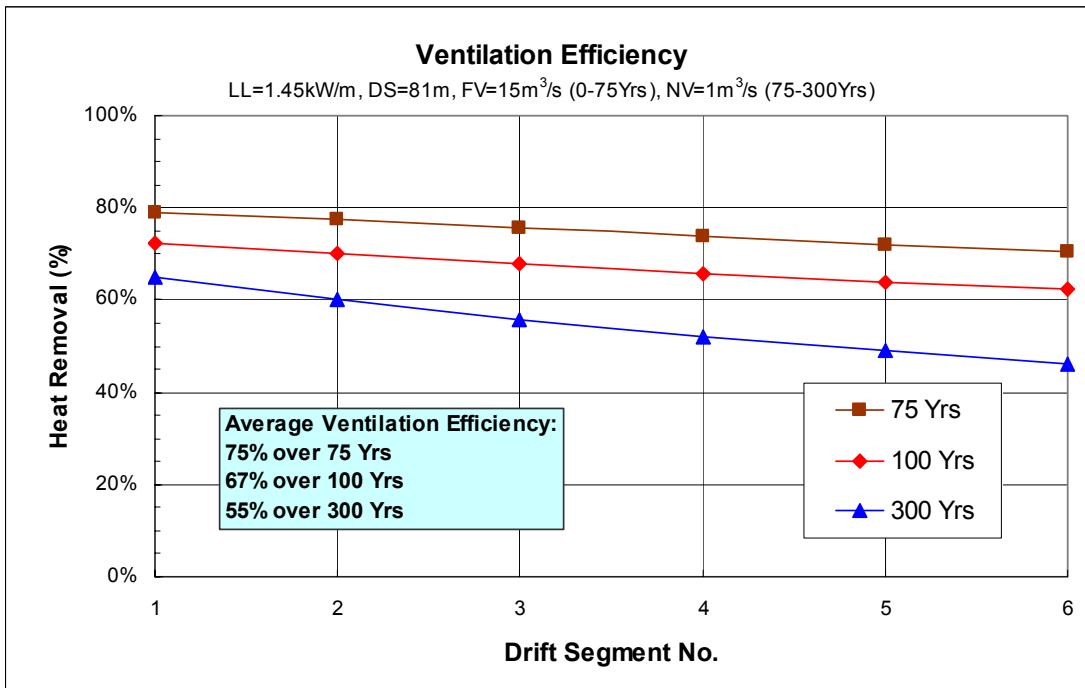
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XII-3, p. XII-4.

Figure XII-3. Average Waste Package Surface Temperatures for Case 11: HF7N1C8



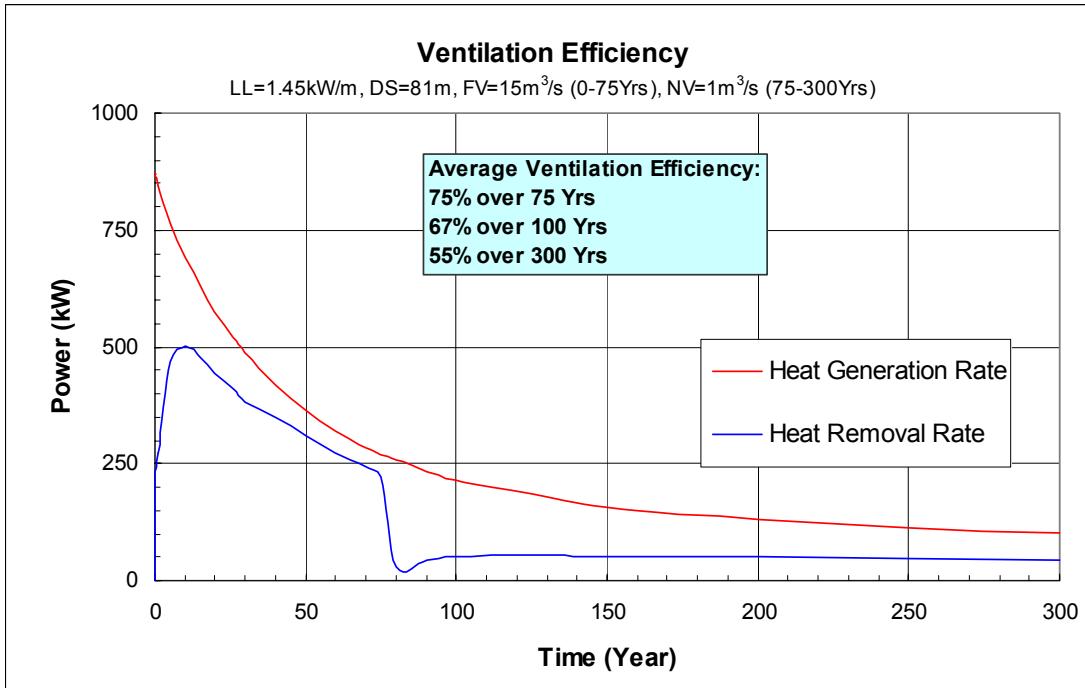
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 11: HF7N1C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XII-5. Average Heat Removal Rates at Different Drift Segments for Case 11: HF7N1C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XII-6. Overall Heat Generation and Removal Rates at Different Time for Case 11: HF7N1C8

ATTACHMENT XIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 12: HF7N3C8

ATTACHMENT XIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 12: HF7N3C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 75 years and a natural ventilation air flow rate of 3 m³/s from 75 to 300 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XIII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 3 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	34.02	37.16	40.30	43.44	46.57	49.69
70.00	33.06	35.87	38.68	41.49	44.30	47.11
75.00	32.63	35.24	37.84	40.43	43.01	45.58
80.00	45.84	50.30	54.19	57.65	60.79	63.67
90.00	47.47	53.82	59.33	64.14	68.37	72.12
100.00	46.29	52.90	58.87	64.25	69.09	73.44
125.00	44.25	50.63	56.55	62.01	67.04	71.65
150.00	41.90	47.79	53.33	58.54	63.42	67.97
200.00	39.55	44.85	49.93	54.77	59.37	63.74
250.00	38.08	42.87	47.50	51.94	56.24	60.35
300.00	37.03	41.45	45.75	49.90	53.90	57.77

Source: DTN: MO0010MWDANS03.005

Table XIII-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 3 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	28.28	31.57	34.85	38.14	41.42	44.70
70.00	27.92	30.84	33.77	36.70	39.63	42.56
75.00	27.69	30.37	33.05	35.72	38.39	41.06
80.00	31.02	36.12	40.54	44.44	47.94	51.16
90.00	33.69	41.17	47.62	53.21	58.10	62.40
100.00	33.69	41.55	48.62	54.96	60.63	65.70
125.00	33.03	40.48	47.36	53.70	59.51	64.83
150.00	32.14	38.90	45.27	51.25	56.84	62.05
200.00	31.20	37.17	42.88	48.33	53.52	58.43
250.00	30.44	35.72	40.84	45.77	50.52	55.08
300.00	29.94	34.75	39.42	43.94	48.33	52.56

Source: DTN: MO0010MWDANS03.005

Table XIII-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 3 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	46.17	49.10	52.03	54.96	57.90	60.83
70.00	43.97	46.61	49.25	51.90	54.55	57.20
75.00	42.99	45.44	47.89	50.33	52.77	55.20
80.00	57.06	61.26	64.91	68.16	71.10	73.81
90.00	57.35	63.40	68.64	73.23	77.27	80.85
100.00	55.41	61.71	67.42	72.57	77.22	81.39
125.00	52.23	58.35	64.03	69.28	74.12	78.57
150.00	48.75	54.42	59.77	64.81	69.53	73.95
200.00	45.31	50.44	55.37	60.07	64.54	68.80
250.00	43.19	47.84	52.33	56.66	60.85	64.86
300.00	41.67	45.98	50.16	54.20	58.11	61.89

Source: DTN: MO0010MWDANS03.005

Table XIII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-75 Years), and 3 m³/s (75-300 Years) (Drift Spacing = 81 m)

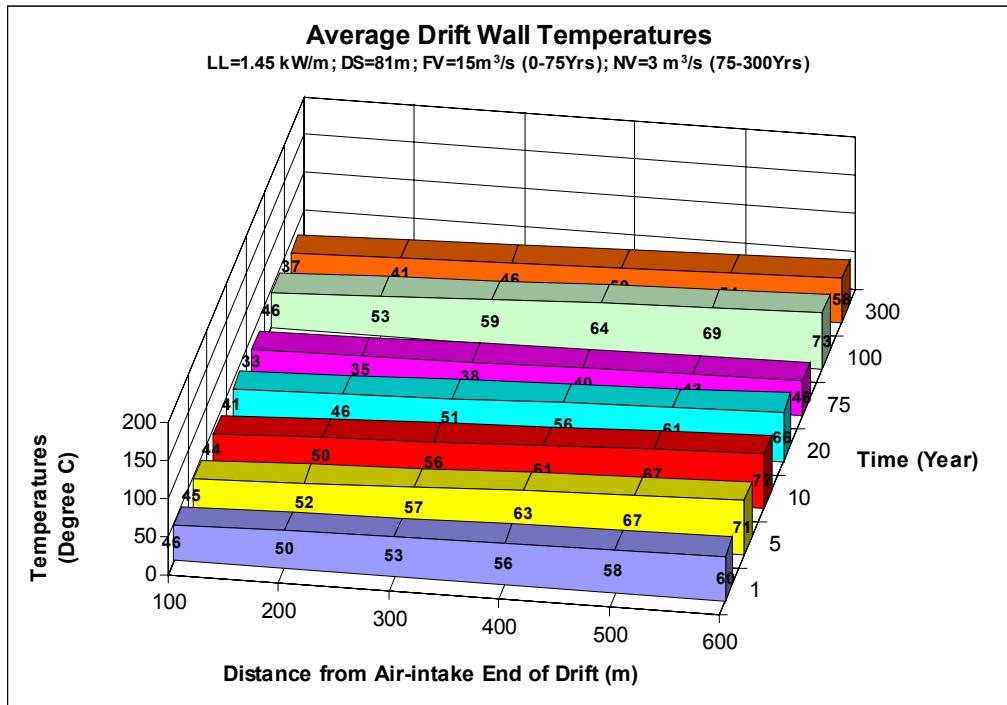
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	45.41	45.44	45.46	45.45	45.40	45.32
70.00	40.40	40.45	40.49	40.51	40.52	40.51
75.00	37.16	37.11	37.05	37.01	36.96	36.91
80.00	15.71	13.32	11.52	10.17	9.15	8.38
90.00	22.67	19.51	16.83	14.60	12.75	11.23
100.00	22.67	20.52	18.46	16.54	14.79	13.23
125.00	20.94	19.44	17.96	16.53	15.17	13.87
150.00	18.63	17.63	16.62	15.60	14.60	13.61
200.00	16.18	15.56	14.91	14.23	13.53	12.82
250.00	14.19	13.79	13.35	12.88	12.39	11.89
300.00	12.88	12.54	12.19	11.81	11.44	11.04

Source: DTN: MO0010MWDANS03.005

Table XIII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-75 Years), and 3 m³/s (75-300 Years) (Drift Spacing = 81 m)

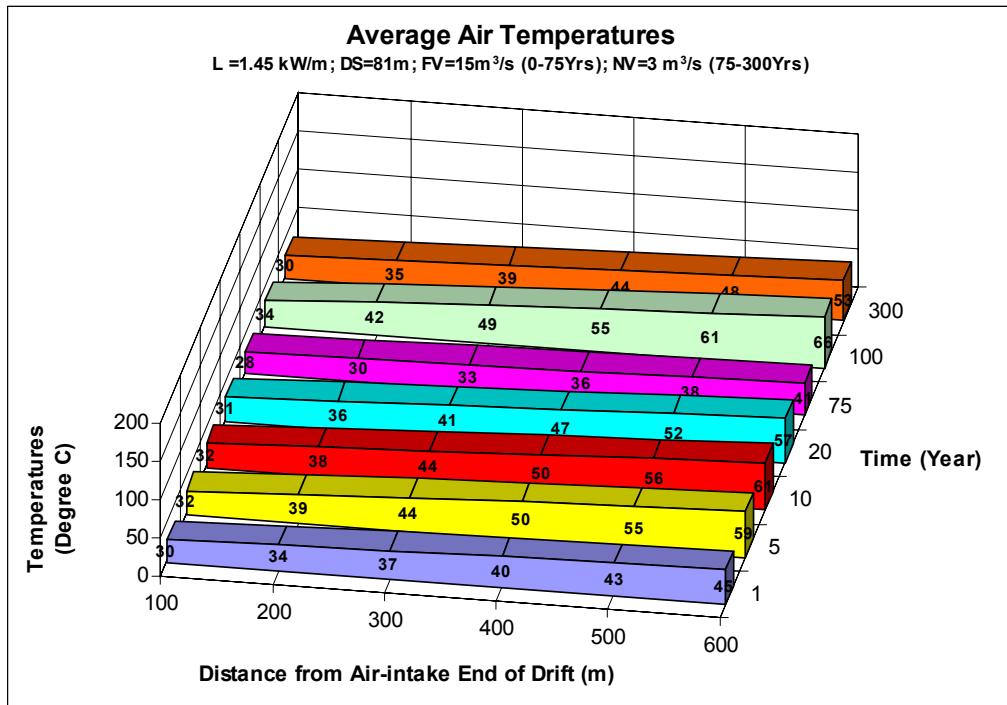
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07			
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31			
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37			
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24			
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48			
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32			
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75			
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73			
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19			
60.00	36.88%	320.81	342.85	108121.88	60.00	272.48	290.35	91565.99			
70.00	32.81%	285.42	303.12	95590.81	70.00	242.88	257.68	81262.48			
75.00	31.03%	269.93	277.67	43783.66	75.00	222.20	232.54	36667.50			
80.00	29.47%	256.40	270.91	85434.15	80.00	68.25	155.57	49059.34			
90.00	26.76%	232.84	244.62	77142.91	90.00	97.60	82.92	26150.77			
100.00	24.52%	213.32	223.08	70349.62	100.00	106.20	101.90	32134.84			
125.00	21.21%	184.50	198.91	156819.84	125.00	103.93	105.06	82831.08			
150.00	17.89%	155.68	170.09	134098.48	150.00	96.69	100.31	79082.02			
200.00	14.85%	129.19	142.43	224589.03	200.00	87.23	91.96	144999.01			
250.00	13.03%	113.33	121.26	191201.22	250.00	78.49	82.86	130649.44			
300.00	11.76%	102.34	107.84	170036.07	300.00	71.91	75.20	118577.58			
Total heat generated in 75 years (GJ)				1123999.12	Total heat removed in 75 years (GJ)			839930.78			
Total heat generated in 100 years (GJ)				1356925.79	Total heat removed in 100 years (GJ)			947275.73			
Total heat generated in 300 years (GJ)				2233670.43	Total heat removed in 300 years (GJ)			1503414.86			
Percentage of total heat removal in 75 years = 75%											
Percentage of total heat removal in 100 years = 70%											
Percentage of total heat removal in 300 years = 67%											

Source: DTN: MO0010MWDANS03.005



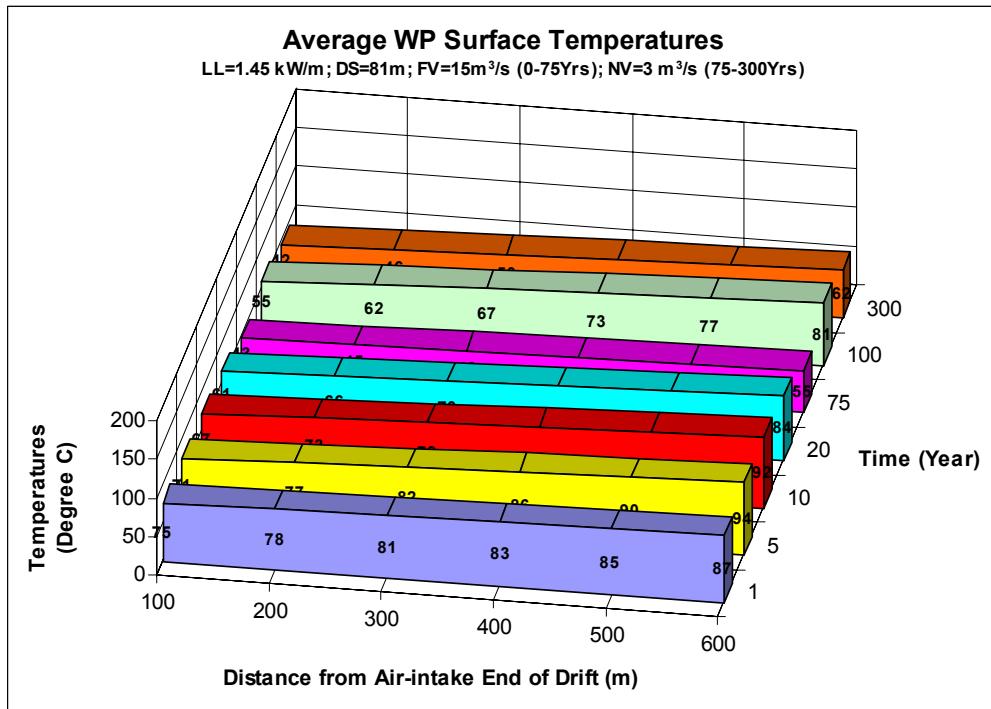
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table XIII-1, p. XIII-2.

Figure XIII-1. Average Drift Wall Temperatures for Case 12: HF7N3C8



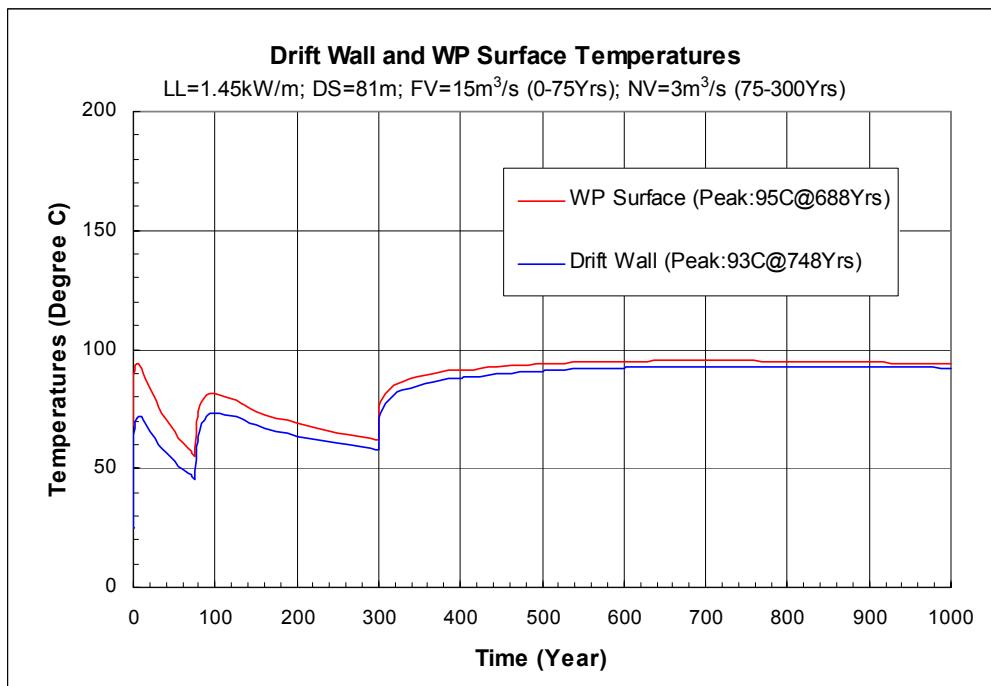
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
 For obliterated numbers, see Table XIII-2, p. XIII-3.

Figure XIII-2. Average Air Temperatures for Case 12: HF7N3C8



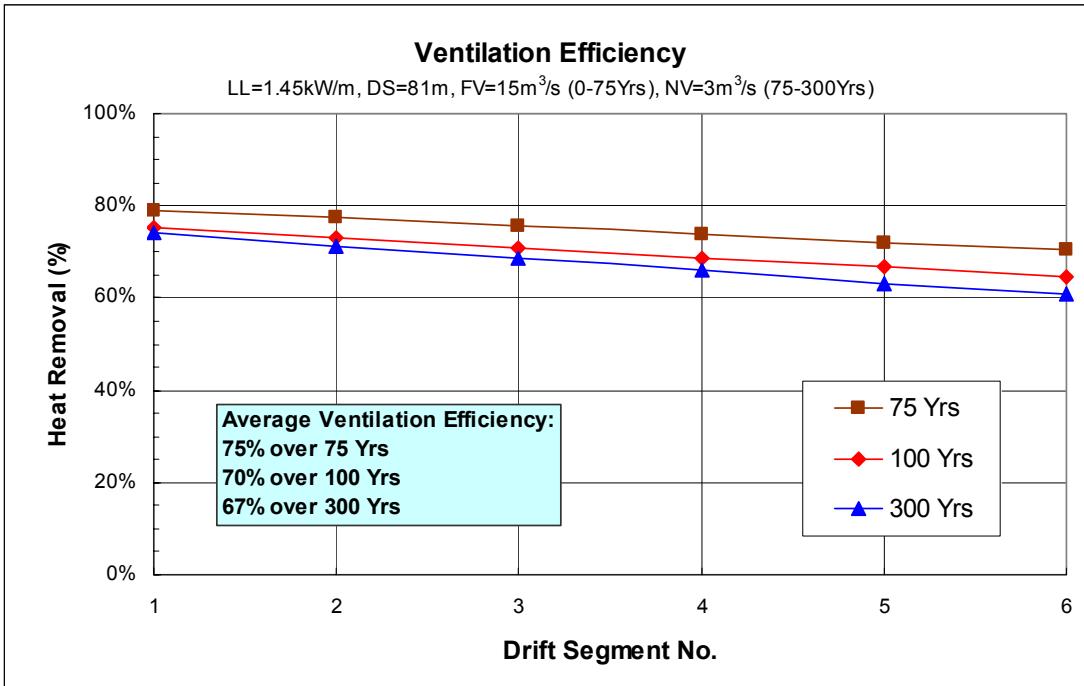
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XIII-3, p. XIII-4.

Figure XIII-3. Average Waste Package Surface Temperatures for Case 12: HF7N3C8



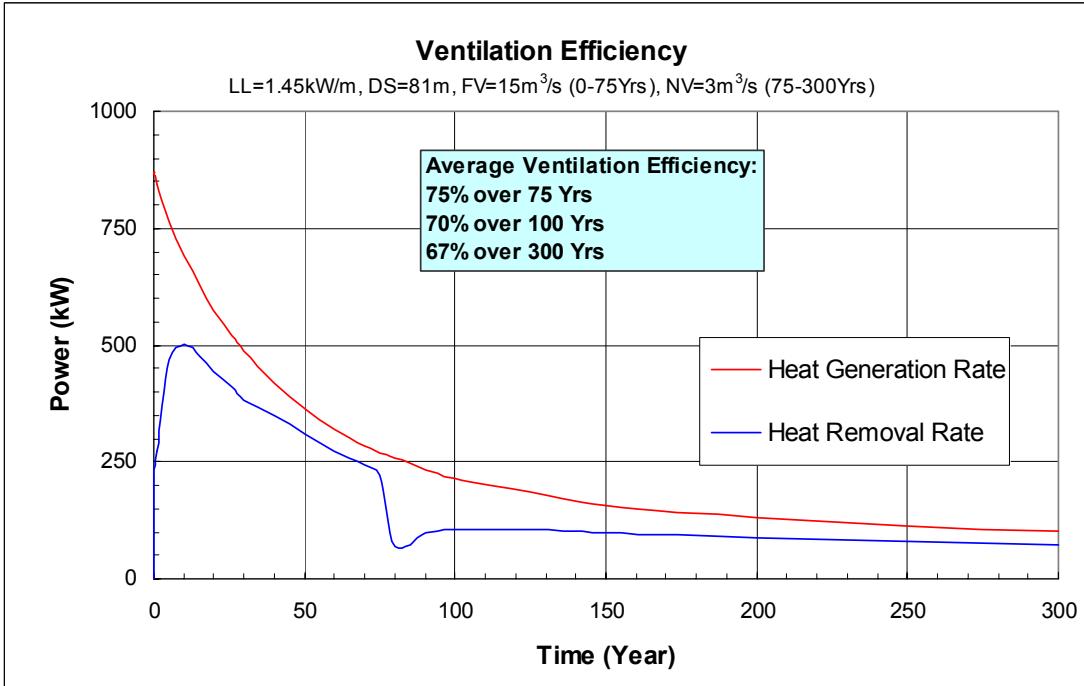
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 12: HF7N3C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIII-5. Average Heat Removal Rates at Different Drift Segments for Case 12: HF7N3C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIII-6. Overall Heat Generation and Removal Rates at Different Time for Case 12: HF7N3C8

ATTACHMENT XIV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 13: HF7N5C8

ATTACHMENT XIV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 13: HF7N5C8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 75 years and a natural ventilation air flow rate of 5 m³/s from 75 to 300 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XIV-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 5 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	34.02	37.16	40.30	43.44	46.57	49.69
70.00	33.06	35.87	38.68	41.49	44.30	47.11
75.00	32.63	35.24	37.84	40.43	43.01	45.58
80.00	40.84	44.68	48.19	51.42	54.44	57.28
90.00	40.94	45.89	50.42	54.55	58.35	61.86
100.00	39.92	44.83	49.47	53.85	57.96	61.82
125.00	38.27	42.87	47.30	51.55	55.62	59.50
150.00	36.50	40.64	44.68	48.60	52.41	56.10
200.00	34.76	38.39	41.98	45.50	48.97	52.36
250.00	33.70	36.91	40.10	43.25	46.37	49.45
300.00	32.94	35.87	38.77	41.64	44.50	47.31

Source: DTN: MO0010MWDANS03.005

Table XIV-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 5 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	28.28	31.57	34.85	38.14	41.42	44.70
70.00	27.92	30.84	33.77	36.70	39.63	42.56
75.00	27.69	30.37	33.05	35.72	38.39	41.06
80.00	29.65	33.82	37.61	41.10	44.34	47.40
90.00	31.01	36.47	41.43	45.96	50.11	53.92
100.00	30.79	36.27	41.45	46.30	50.85	55.10
125.00	30.28	35.37	40.26	44.95	49.42	53.69
150.00	29.63	34.16	38.58	42.88	47.05	51.08
200.00	28.97	32.90	36.78	40.60	44.35	48.02
250.00	28.44	31.87	35.27	38.65	41.99	45.29
300.00	28.10	31.18	34.24	37.29	40.30	43.29

Source: DTN: MO0010MWDANS03.005

Table XIV-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-75 Years), and 5 m³/s (75-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	46.17	49.10	52.03	54.96	57.90	60.83
70.00	43.97	46.61	49.25	51.90	54.55	57.20
75.00	42.99	45.44	47.89	50.33	52.77	55.20
80.00	51.83	55.45	58.75	61.79	64.63	67.30
90.00	50.79	55.51	59.81	63.75	67.37	70.72
100.00	49.01	53.69	58.12	62.31	66.24	69.94
125.00	46.23	50.63	54.88	58.96	62.87	66.61
150.00	43.30	47.29	51.18	54.96	58.65	62.21
200.00	40.47	43.98	47.46	50.88	54.24	57.53
250.00	38.75	41.86	44.96	48.03	51.07	54.06
300.00	37.53	40.38	43.20	46.00	48.78	51.53

Source: DTN: MO0010MWDANS03.005

Table XIV-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-75 Years), and 5 m³/s (75-300 Years) (Drift Spacing = 81 m)

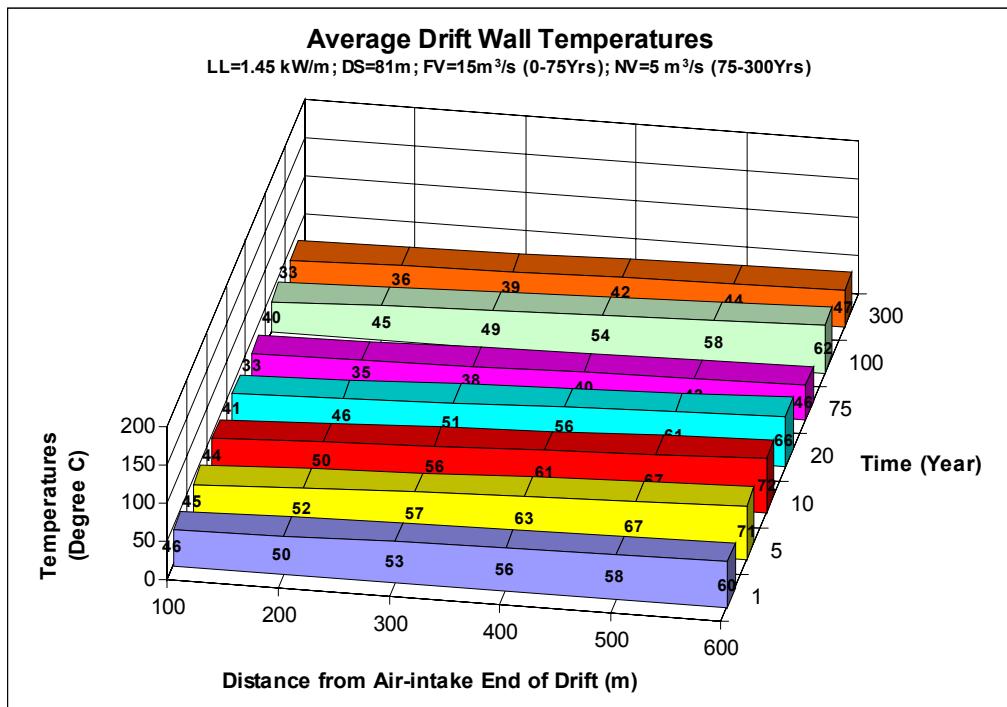
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	45.41	45.44	45.46	45.45	45.40	45.32
70.00	40.40	40.45	40.49	40.51	40.52	40.51
75.00	37.16	37.11	37.05	37.01	36.96	36.91
80.00	20.64	18.49	16.79	15.46	14.40	13.56
90.00	26.63	24.21	22.02	20.08	18.39	16.91
100.00	25.65	24.33	22.94	21.53	20.15	18.84
125.00	23.40	22.57	21.69	20.79	19.86	18.91
150.00	20.52	20.09	19.60	19.06	18.49	17.88
200.00	17.59	17.43	17.21	16.94	16.63	16.29
250.00	15.25	15.19	15.10	14.97	14.82	14.63
300.00	13.74	13.67	13.58	13.48	13.38	13.26

Source: DTN: MO0010MWDANS03.005

Table XIV-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-75 Years), and 5 m³/s (75-300 Years) (Drift Spacing = 81 m)

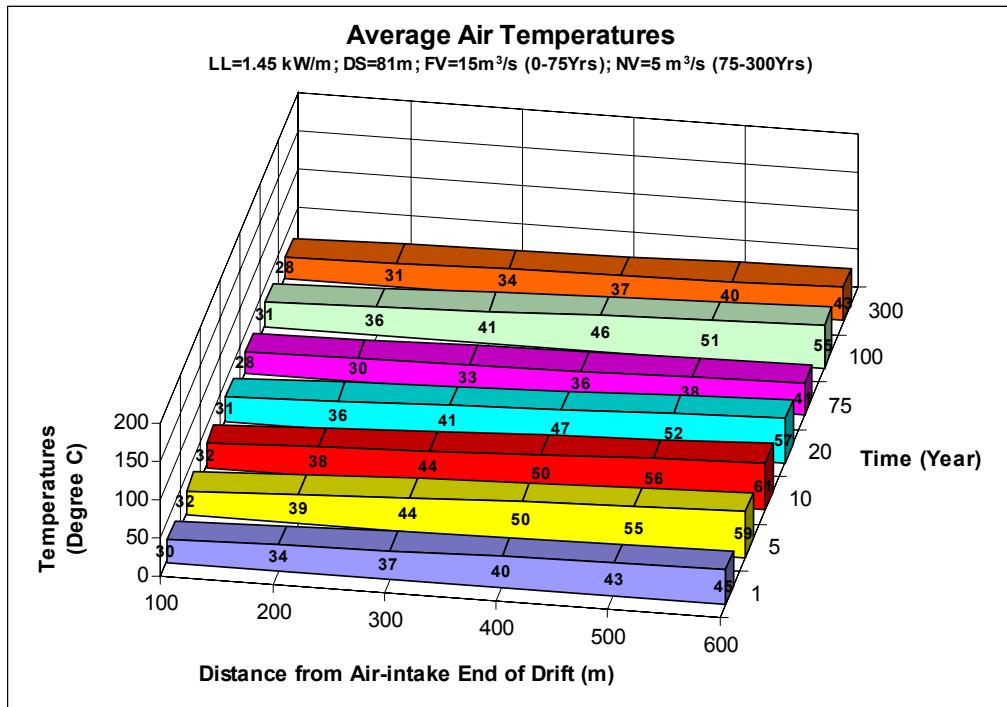
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07			
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31			
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37			
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24			
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48			
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32			
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75			
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73			
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19			
60.00	36.88%	320.81	342.85	108121.88	60.00	272.48	290.35	91565.99			
70.00	32.81%	285.42	303.12	95590.81	70.00	242.88	257.68	81262.48			
75.00	31.03%	269.93	277.67	43783.66	75.00	222.20	232.54	36667.50			
80.00	29.47%	256.40	270.91	85434.15	80.00	99.33	171.11	53959.86			
90.00	26.76%	232.84	244.62	77142.91	90.00	128.24	113.78	35882.60			
100.00	24.52%	213.32	223.08	70349.62	100.00	133.44	130.84	41261.99			
125.00	21.21%	184.50	198.91	156819.84	125.00	127.21	130.33	102748.97			
150.00	17.89%	155.68	170.09	134098.48	150.00	115.64	121.43	95732.41			
200.00	14.85%	129.19	142.43	224589.03	200.00	102.09	108.87	171660.16			
250.00	13.03%	113.33	121.26	191201.22	250.00	89.97	96.03	151417.80			
300.00	11.76%	102.34	107.84	170036.07	300.00	81.11	85.54	134882.34			
Total heat generated in 75 years (GJ)				1123999.12	Total heat removed in 75 years (GJ)			839930.78			
Total heat generated in 100 years (GJ)				1356925.79	Total heat removed in 100 years (GJ)			971035.23			
Total heat generated in 300 years (GJ)				2233670.43	Total heat removed in 300 years (GJ)			1627476.91			
Percentage of total heat removal in 75 years = 75%											
Percentage of total heat removal in 100 years = 72%											
Percentage of total heat removal in 300 years = 73%											

Source: DTN: MO0010MWDANS03.005



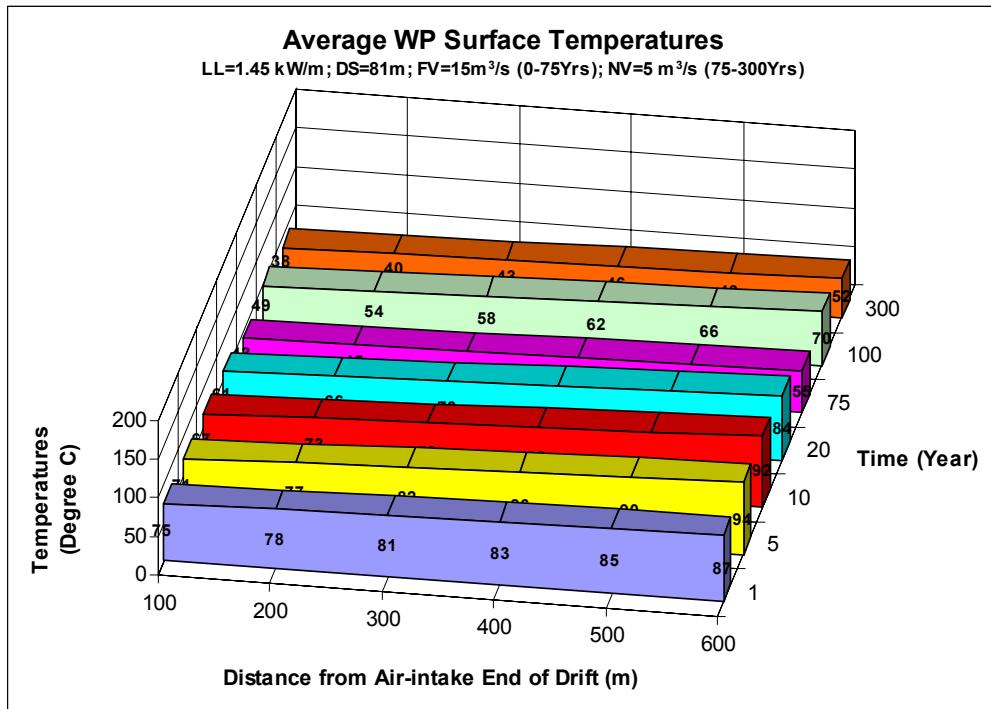
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XIV-1, p. XIV-2.

Figure XIV-1. Average Drift Wall Temperatures for Case 13: HF7N5C8



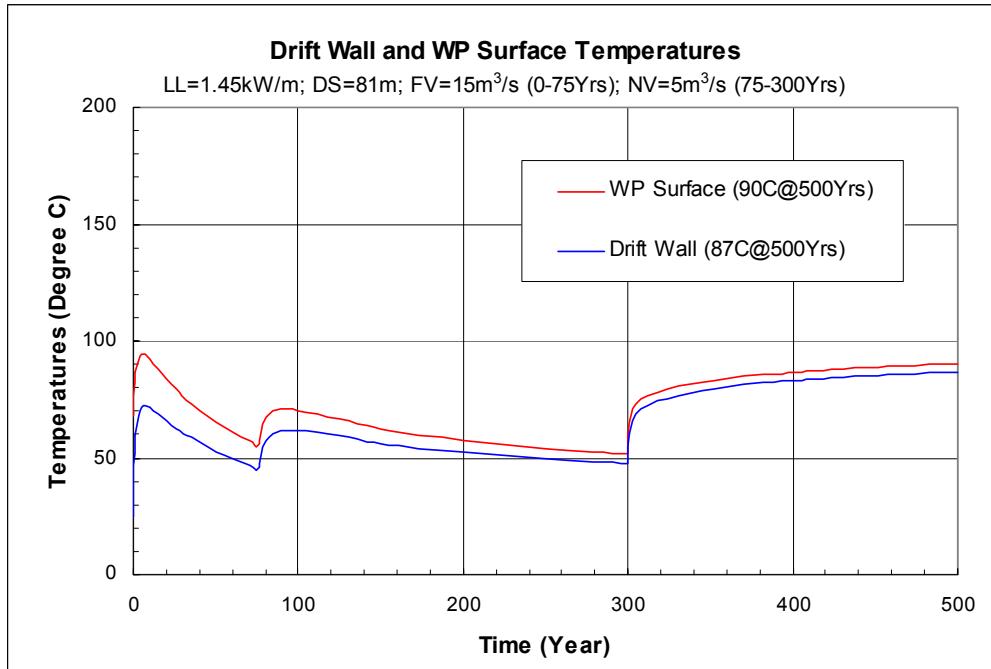
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XIV-2, p. XIV-3.

Figure XIV-2. Average Air Temperatures for Case 13: HF7N5C8



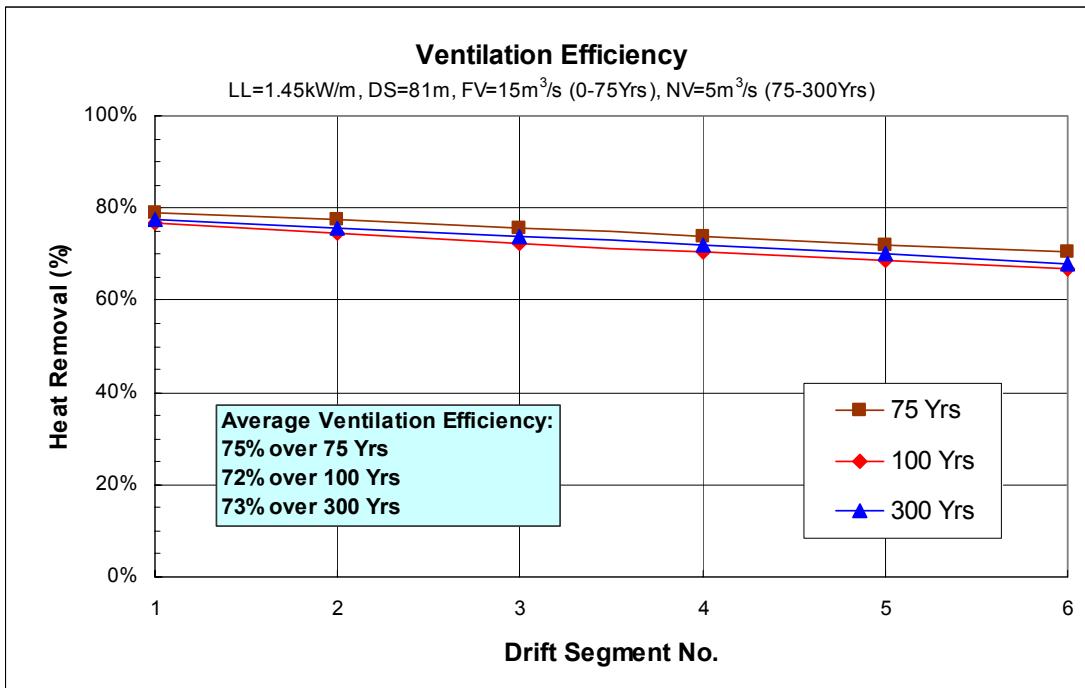
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XIV-3, p. XIV-4.

Figure XIV-3. Average Waste Package Surface Temperatures for Case 13: HF7N5C8



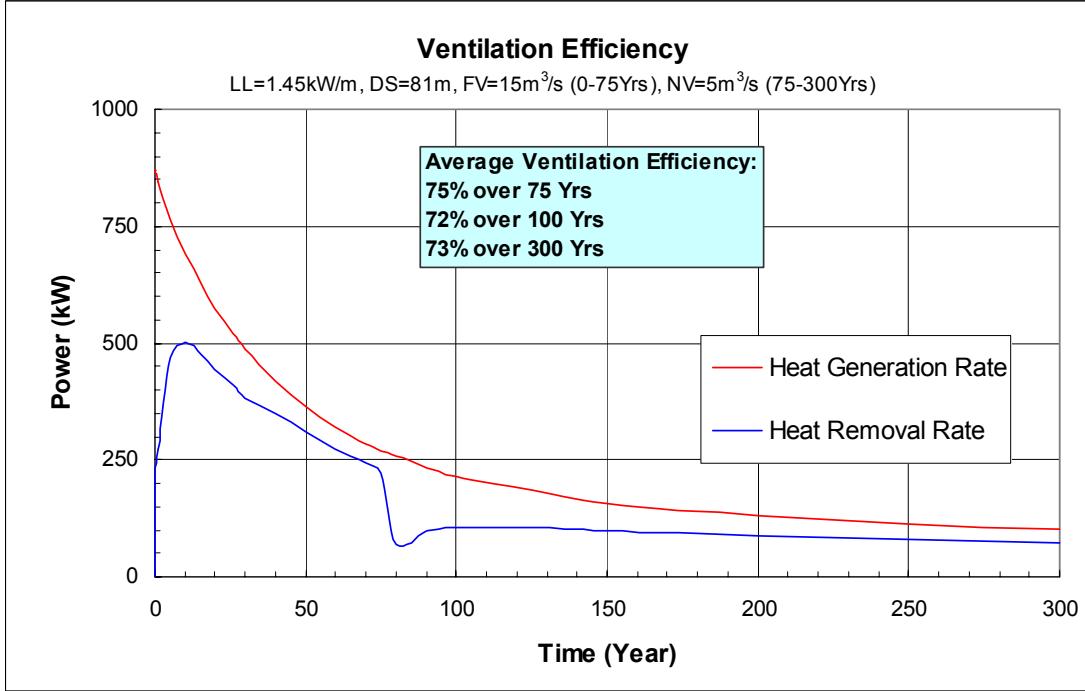
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIV-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 13: HF7N5C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIV-5. Average Heat Removal Rates at Different Drift Segments for Case 13: HF7N5C8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIV-6. Overall Heat Generation and Removal Rates at Different Time for Case 13: HF7N5C8

ATTACHMENT XV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 14: HF5N3V8

ATTACHMENT XV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 14: HF5N3V8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 3 m³/s from 50 to 100 years and 1.5 m³/s from 100 to 300 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XV-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	52.38	58.24	63.32	67.80	71.84	75.52
70.00	52.57	60.53	67.43	73.43	78.70	83.35
80.00	50.58	58.56	65.79	72.31	78.16	83.42
90.00	48.79	56.40	63.41	69.84	75.73	81.12
100.00	47.24	54.47	61.17	67.38	73.13	78.43
125.00	53.31	61.15	67.98	73.99	79.35	84.16
150.00	51.00	59.40	66.69	73.06	78.64	83.57
200.00	48.01	56.07	63.28	69.70	75.41	80.49
250.00	46.04	53.60	60.48	66.72	72.36	77.44
300.00	44.57	51.74	58.33	64.36	69.86	74.87

Source: DTN: MO0010MWDANS03.005

Table XV-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 3 m^3/s (50-100 Years), and 1.5 m^3/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	32.88	39.58	45.39	50.53	55.15	59.38
70.00	35.94	45.39	53.55	60.63	66.81	72.24
80.00	35.51	45.06	53.68	61.42	68.35	74.55
90.00	34.75	43.76	52.05	59.66	66.62	72.97
100.00	34.08	42.53	50.38	57.65	64.38	70.59
125.00	36.34	46.06	54.52	61.97	68.61	74.57
150.00	37.02	47.39	56.35	64.13	70.93	76.91
200.00	35.81	45.52	54.18	61.88	68.71	74.76
250.00	34.70	43.59	51.69	59.03	65.67	71.65
300.00	33.93	42.19	49.79	56.77	63.15	68.96

Source: DTN: MO0010MWDANS03.005

Table XV-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years)
(Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	65.54	70.98	75.69	79.86	83.61	87.04
70.00	64.13	71.61	78.13	83.80	88.78	93.19
80.00	61.09	68.63	75.48	81.67	87.25	92.27
90.00	58.47	65.69	72.35	78.48	84.11	89.27
100.00	56.22	63.10	69.49	75.43	80.93	86.03
125.00	61.20	68.71	75.26	81.04	86.19	90.83
150.00	57.72	65.83	72.90	79.06	84.47	89.25
200.00	53.67	61.49	68.50	74.75	80.33	85.28
250.00	51.07	58.42	65.13	71.22	76.73	81.70
300.00	49.15	56.14	62.57	68.46	73.85	78.77

Source: DTN: MO0010MWDANS03.005

Table XV-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

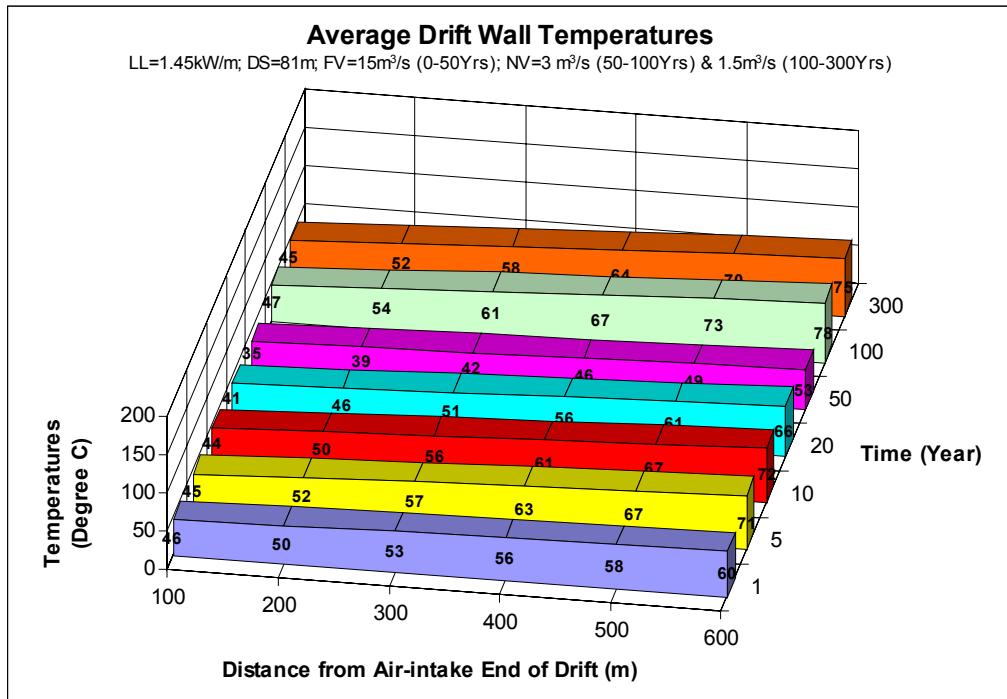
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	20.56	17.49	15.16	13.40	12.06	11.03
70.00	28.55	24.65	21.30	18.48	16.12	14.17
80.00	27.42	24.93	22.50	20.20	18.08	16.16
90.00	25.44	23.51	21.64	19.86	18.16	16.56
100.00	23.70	22.05	20.48	18.97	17.55	16.20
125.00	14.30	12.25	10.66	9.39	8.37	7.51
150.00	15.15	13.06	11.29	9.81	8.57	7.53
200.00	13.63	12.24	10.92	9.70	8.60	7.63
250.00	12.22	11.20	10.21	9.26	8.36	7.53
300.00	11.25	10.41	9.59	8.79	8.04	7.33

Source: DTN: MO0010MWDANS03.005

Table XV-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

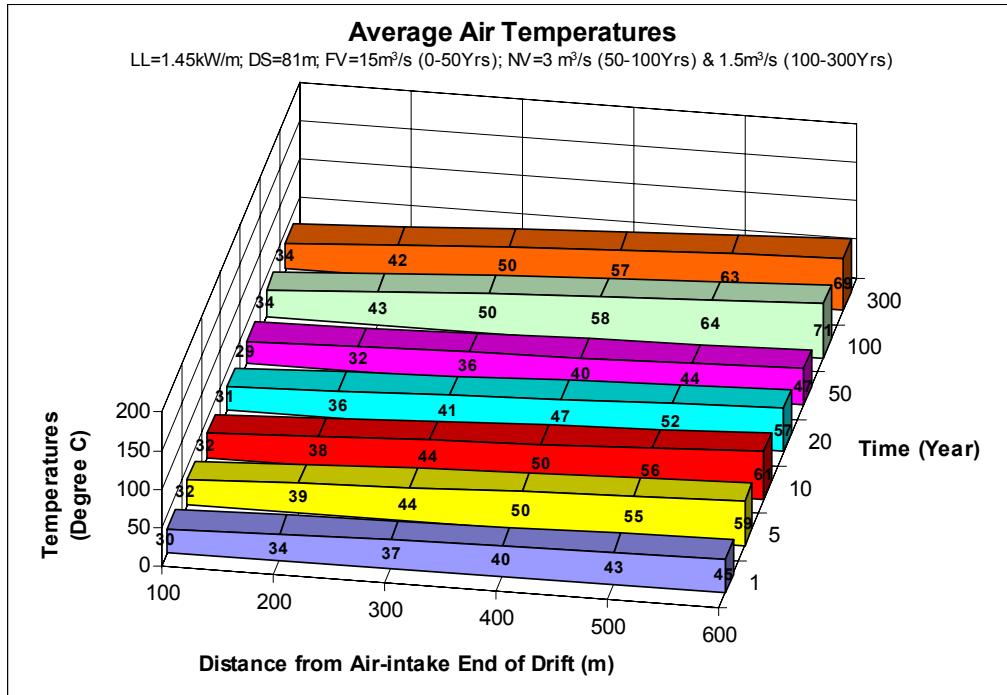
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75				
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73				
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19				
60.00	36.88%	320.81	342.85	108121.88	60.00	89.70	198.96	62745.18				
70.00	32.81%	285.42	303.12	95590.81	70.00	123.26	106.48	33579.91				
80.00	29.47%	256.40	270.91	85434.15	80.00	129.28	126.27	39821.71				
90.00	26.76%	232.84	244.62	77142.91	90.00	125.18	127.23	40123.27				
100.00	24.52%	213.32	223.08	70349.62	100.00	118.95	122.06	38493.67				
125.00	21.21%	184.50	198.91	156819.84	125.00	62.48	90.71	71518.35				
150.00	17.89%	155.68	170.09	134098.48	150.00	65.42	63.95	50415.54				
200.00	14.85%	129.19	142.43	224589.03	200.00	62.71	64.06	101016.39				
250.00	13.03%	113.33	121.26	191201.22	250.00	58.79	60.75	95789.35				
300.00	11.76%	102.34	107.84	170036.07	300.00	55.41	57.10	90029.43				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		630434.80					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		845198.54					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1253967.61					
Percentage of total heat removal in 50 years = 72%												
Percentage of total heat removal in 100 years = 64%												
Percentage of total heat removal in 300 years = 57%												

Source: DTN: MO0010MWDANS03.005



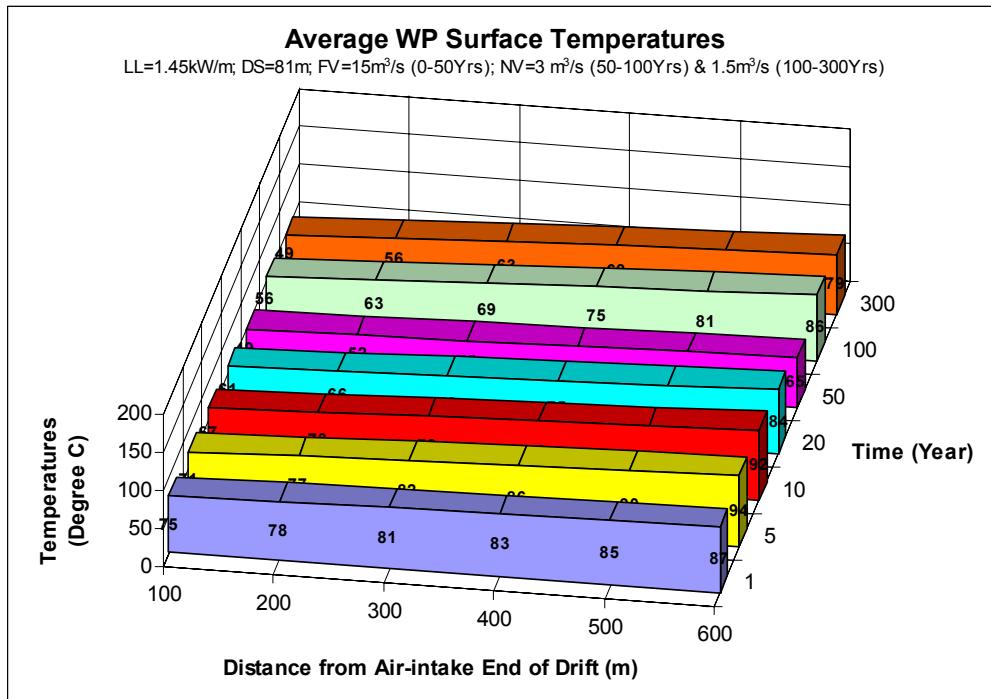
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XV-1, p. XV-2.

Figure XV-1. Average Drift Wall Temperatures for Case 14: HF5N3V8



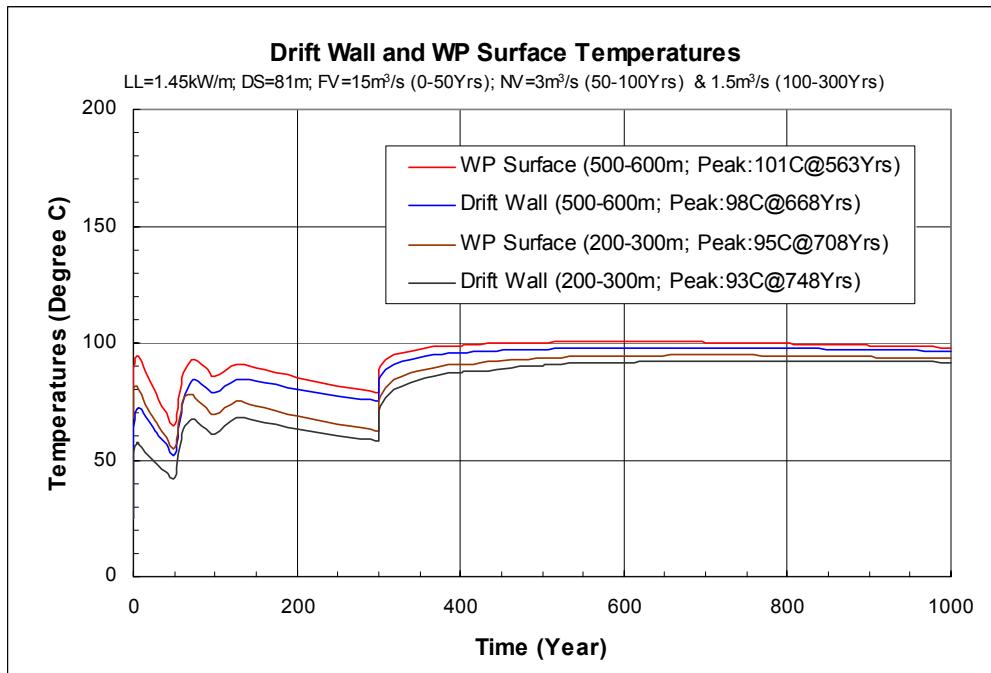
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XV-2, p. XV-3.

Figure XV-2. Average Air Temperatures for Case 14: HF5N3V8



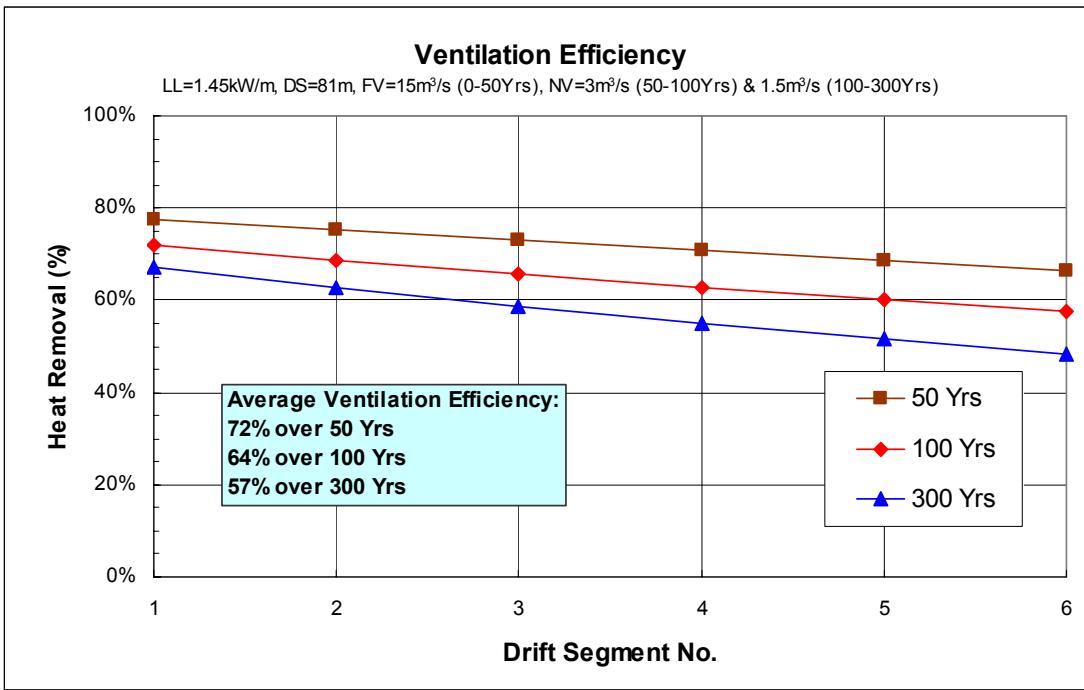
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XV-3, p. XV-4.

Figure XV-3. Average Waste Package Surface Temperatures for Case 14: HF5N3V8



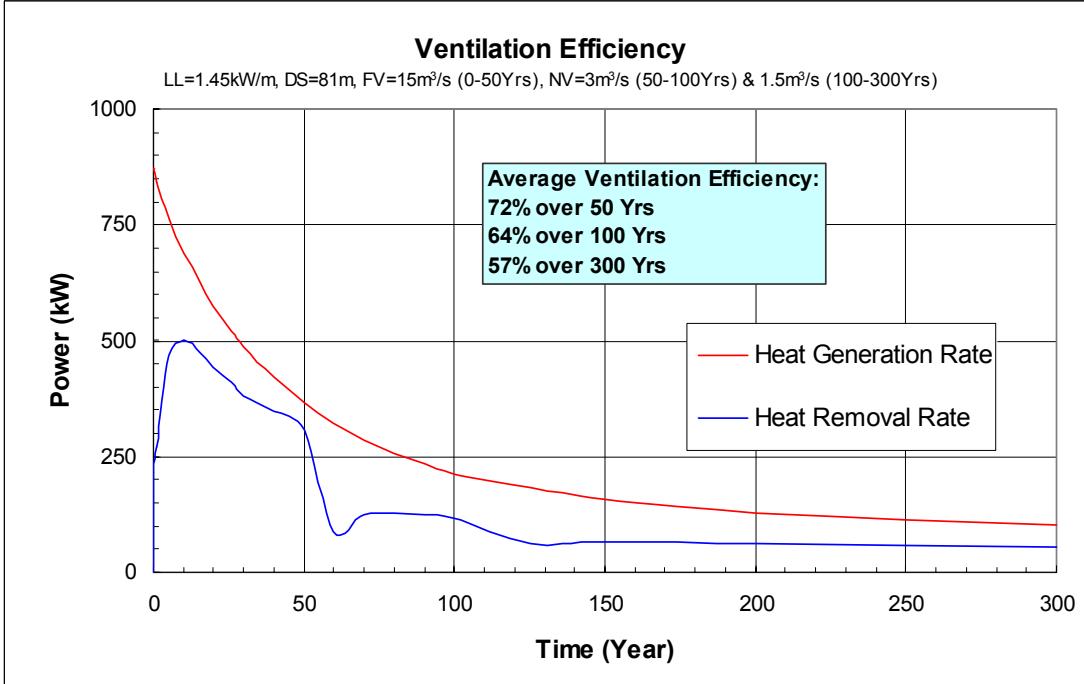
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XV-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 14: HF5N3V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XV-5. Average Heat Removal Rates at Different Drift Segments for Case 14: HF5N3V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XV-6. Overall Heat Generation and Removal Rates at Different Time for Case 14: HF5N3V8

ATTACHMENT XVI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 15: HF5N5V8

ATTACHMENT XVI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 15: HF5N5V8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XVI-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	45.39	50.37	54.90	59.06	62.94	66.58
70.00	44.51	50.65	56.26	61.39	66.10	70.44
80.00	42.88	48.79	54.39	59.66	64.62	69.27
90.00	41.50	47.02	52.31	57.37	62.19	66.78
100.00	40.33	45.50	50.48	55.27	59.87	64.26
125.00	45.83	51.67	56.96	61.80	66.28	70.45
150.00	43.87	50.19	55.93	61.15	65.91	70.28
200.00	41.43	47.33	52.86	58.03	62.84	67.30
250.00	39.86	45.27	50.41	55.29	59.91	64.26
300.00	38.72	43.76	48.58	53.18	57.57	61.75

Source: DTN: MO0010MWDANS03.005

Table XVI-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	31.03	36.45	41.39	45.96	50.21	54.22
70.00	32.49	39.32	45.54	51.22	56.43	61.21
80.00	31.99	38.63	44.90	50.81	56.34	61.51
90.00	31.42	37.58	43.49	49.13	54.51	59.62
100.00	30.94	36.66	42.18	47.48	52.56	57.44
125.00	32.51	39.25	45.36	50.97	56.16	60.99
150.00	33.09	40.40	47.02	53.02	58.49	63.50
200.00	32.16	38.91	45.23	51.11	56.57	61.62
250.00	31.34	37.40	43.18	48.67	53.85	58.73
300.00	30.78	36.34	41.67	46.77	51.64	56.27

Source: DTN: MO0010MWDANS03.005

Table XVI-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years)
(Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	58.51	63.14	67.34	71.21	74.83	78.22
70.00	56.18	61.94	67.23	72.07	76.51	80.62
80.00	53.49	59.06	64.35	69.34	74.06	78.48
90.00	51.25	56.48	61.49	66.31	70.90	75.28
100.00	49.35	54.27	59.01	63.58	67.96	72.17
125.00	53.89	59.47	64.54	69.18	73.48	77.48
150.00	50.72	56.82	62.37	67.42	72.03	76.26
200.00	47.19	52.91	58.28	63.31	67.98	72.33
250.00	44.97	50.22	55.23	59.98	64.49	68.73
300.00	43.36	48.27	52.97	57.46	61.75	65.83

Source: DTN: MO0010MWDANS03.005

Table XVI-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

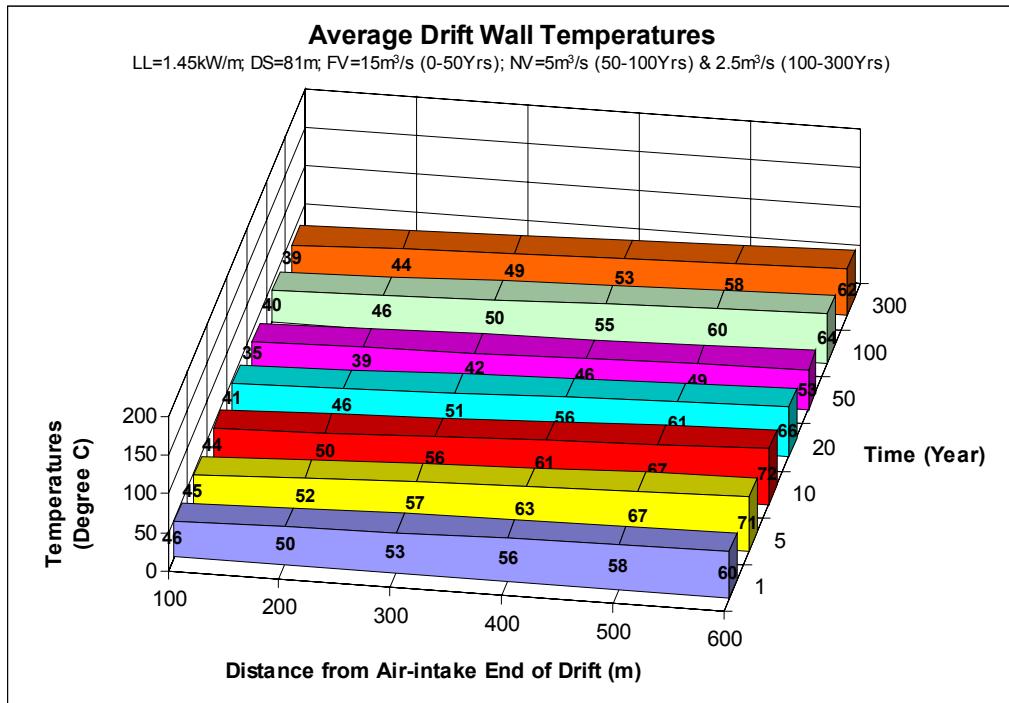
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	26.73	24.05	21.92	20.23	18.88	17.79
70.00	33.22	30.27	27.59	25.19	23.08	21.22
80.00	30.98	29.45	27.83	26.16	24.52	22.93
90.00	28.46	27.33	26.18	25.01	23.84	22.66
100.00	26.34	25.38	24.44	23.50	22.56	21.62
125.00	16.19	14.52	13.18	12.09	11.19	10.42
150.00	17.43	15.76	14.27	12.95	11.80	10.79
200.00	15.44	14.55	13.62	12.68	11.77	10.90
250.00	13.66	13.08	12.46	11.83	11.18	10.52
300.00	12.46	11.98	11.49	11.00	10.49	9.98

Source: DTN: MO0010MWDANS03.005

Table XVI-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

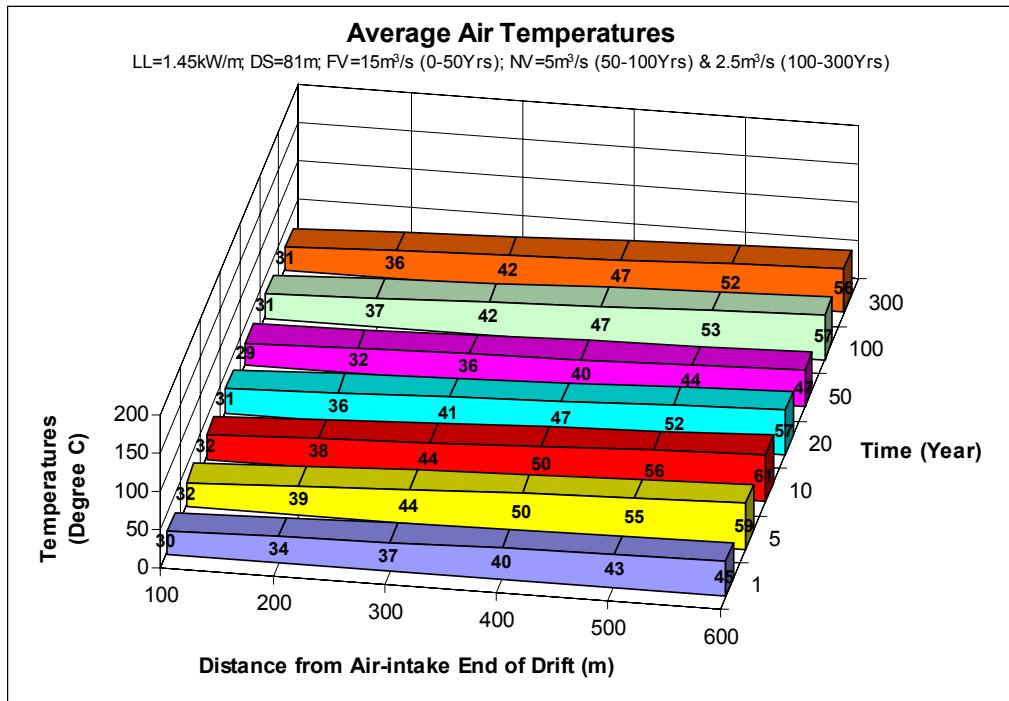
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75				
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73				
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19				
60.00	36.88%	320.81	342.85	108121.88	60.00	129.58	218.90	69033.77				
70.00	32.81%	285.42	303.12	95590.81	70.00	160.57	145.08	45751.71				
80.00	29.47%	256.40	270.91	85434.15	80.00	161.87	161.22	50843.16				
90.00	26.76%	232.84	244.62	77142.91	90.00	153.49	157.68	49725.69				
100.00	24.52%	213.32	223.08	70349.62	100.00	143.84	148.67	46883.25				
125.00	21.21%	184.50	198.91	156819.84	125.00	77.60	110.72	87292.74				
150.00	17.89%	155.68	170.09	134098.48	150.00	83.01	80.30	63310.14				
200.00	14.85%	129.19	142.43	224589.03	200.00	78.96	80.98	127693.79				
250.00	13.03%	113.33	121.26	191201.22	250.00	72.73	75.84	119591.31				
300.00	11.76%	102.34	107.84	170036.07	300.00	67.41	70.07	110488.47				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		630434.80					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		892672.39					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1401048.83					
Percentage of total heat removal in 50 years = 72%												
Percentage of total heat removal in 100 years = 68%												
Percentage of total heat removal in 300 years = 64%												

Source: DTN: MO0010MWDANS03.005



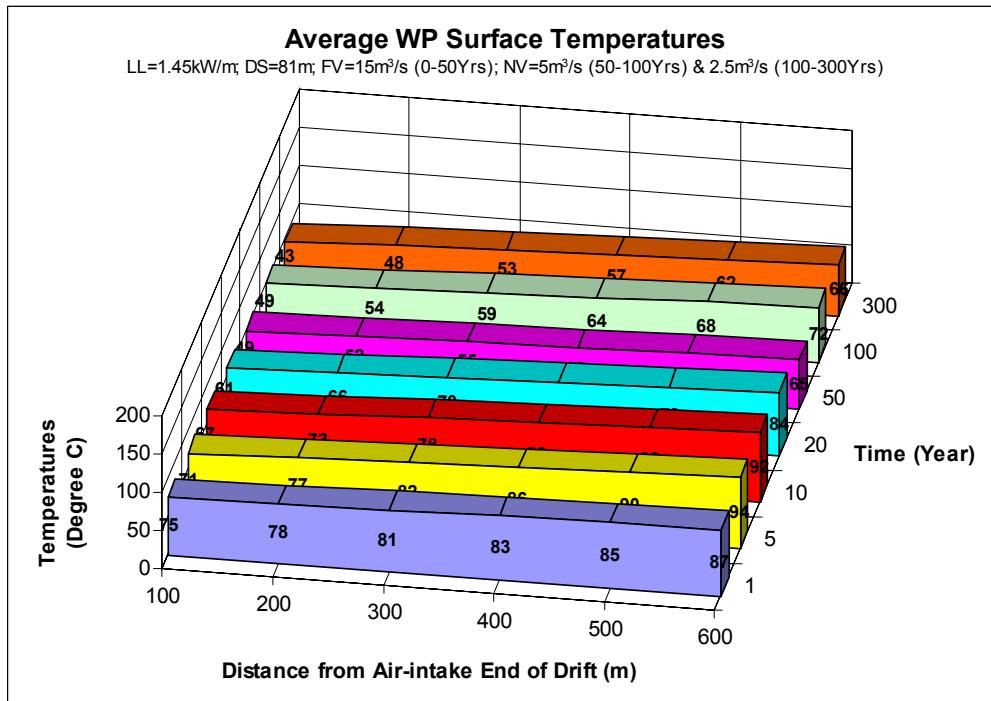
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVI-1, p. XVI-2.

Figure XVI-1. Average Drift Wall Temperatures for Case 15: HF5N5V8



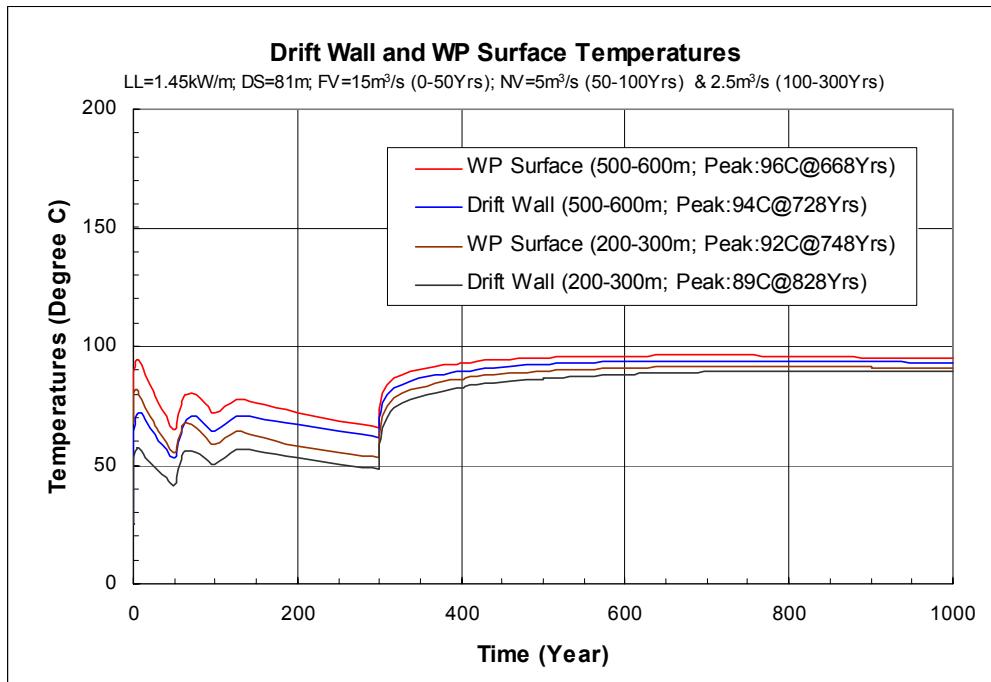
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVI-2, p. XVI-3.

Figure XVI-2. Average Air Temperatures for Case 15: HF5N5V8



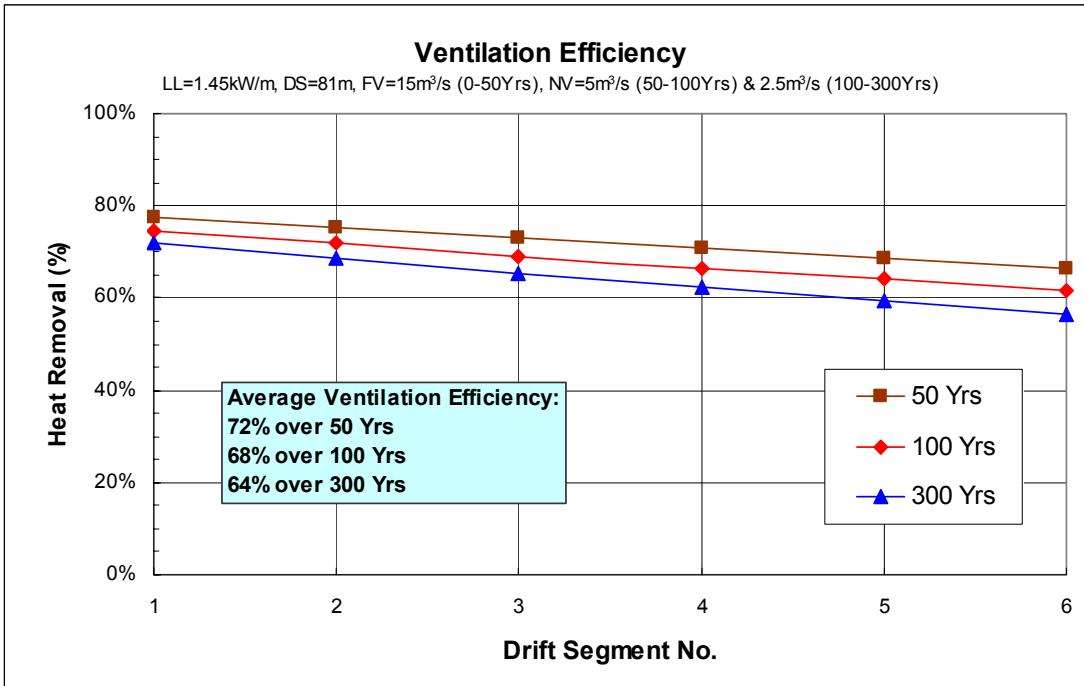
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVI-3, p. XVI-4.

Figure XVI-3. Average Waste Package Surface Temperatures for Case 15: HF5N5V8



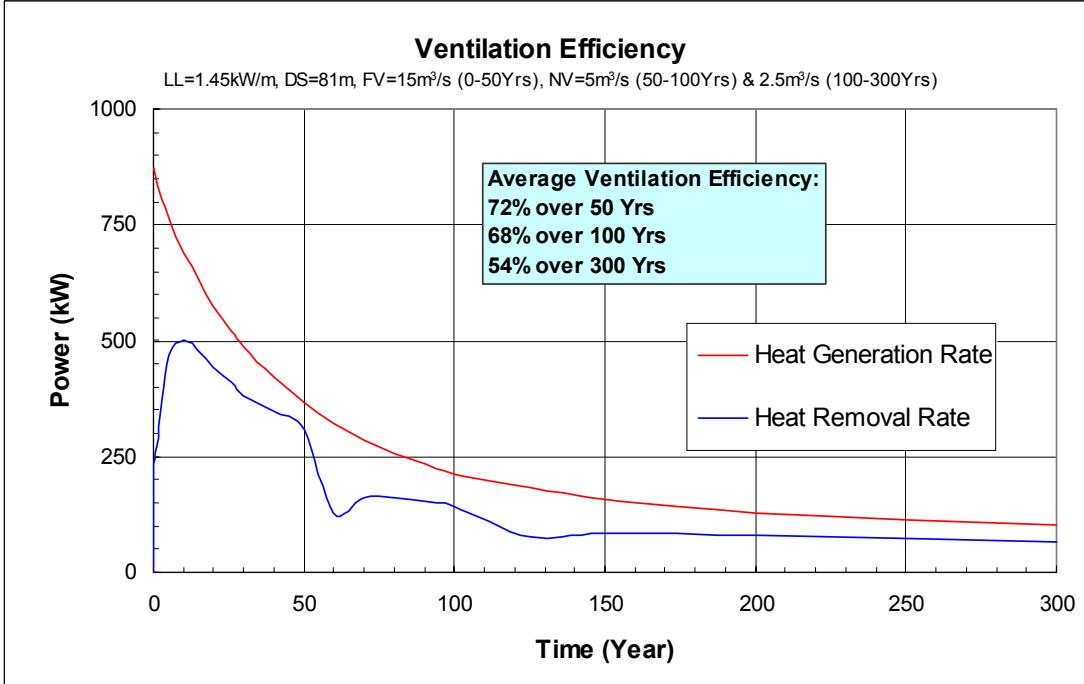
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVI-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 15: HF5N5V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVI-5. Average Heat Removal Rates at Different Drift Segments for Case 15: HF5N5V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVI-6. Overall Heat Generation and Removal Rates at Different Time for Case 15: HF5N5V8

ATTACHMENT XVII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 16: LF5N3V8

ATTACHMENT XVII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 16: LF5N3V8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.0 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 3 m³/s from 50 to 100 years and 1.5 m³/s from 100 to 300 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XVII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	39.31	42.36	44.80	46.85	48.56	49.98
5.00	38.82	43.10	47.07	50.69	53.99	56.97
10.00	37.69	41.81	45.81	49.67	53.37	56.90
15.00	36.70	40.53	44.29	47.96	51.55	55.04
20.00	35.78	39.33	42.83	46.27	49.63	52.94
26.00	34.77	38.05	41.28	44.46	47.60	50.68
30.00	34.18	37.22	40.23	43.19	46.11	48.99
40.00	32.95	35.72	38.46	41.18	43.86	46.51
50.00	31.96	34.39	36.81	39.23	41.64	44.04
60.00	43.72	47.75	51.23	54.32	57.08	59.62
70.00	43.90	49.36	54.10	58.24	61.87	65.07
80.00	42.54	48.04	53.01	57.49	61.53	65.15
90.00	41.30	46.53	51.35	55.78	59.84	63.56
100.00	40.23	45.20	49.80	54.07	58.03	61.68
125.00	44.42	49.81	54.50	58.64	62.33	65.64
150.00	42.86	48.64	53.66	58.05	61.89	65.28
200.00	40.84	46.39	51.36	55.78	59.72	63.22
250.00	39.48	44.69	49.44	53.74	57.63	61.13
300.00	38.47	43.41	47.95	52.10	55.90	59.36

Source: DTN: MO0010MWDANS03.005

Table XVII-2. Average Air Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	28.77	31.94	34.60	36.82	38.67	40.23
5.00	29.87	34.41	38.58	42.38	45.83	48.95
10.00	29.55	33.99	38.29	42.43	46.38	50.13
15.00	29.19	33.30	37.33	41.28	45.13	48.87
20.00	28.86	32.66	36.40	40.07	43.68	47.22
26.00	28.53	32.02	35.46	38.86	42.20	45.49
30.00	28.26	31.49	34.67	37.81	40.91	43.97
40.00	27.95	30.88	33.79	36.66	39.51	42.33
50.00	27.57	30.14	32.71	35.27	37.82	40.35
60.00	30.44	35.06	39.07	42.61	45.80	48.71
70.00	32.55	39.07	44.71	49.60	53.87	57.61
80.00	32.26	38.86	44.81	50.16	54.95	59.23
90.00	31.73	37.95	43.68	48.93	53.74	58.13
100.00	31.26	37.09	42.50	47.52	52.16	56.45
125.00	32.82	39.52	45.35	50.49	55.07	59.19
150.00	33.29	40.44	46.63	52.00	56.69	60.81
200.00	32.47	39.17	45.15	50.47	55.18	59.36
250.00	31.70	37.84	43.44	48.51	53.10	57.22
300.00	31.17	36.87	42.12	46.94	51.35	55.36

Source: DTN: MO0010MWDANS03.005

Table XVII-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	67.93	67.95	67.95	67.95	67.95	67.95
1.00	60.29	63.08	65.36	67.26	68.85	70.18
5.00	57.91	61.82	65.45	68.78	71.82	74.57
10.00	55.09	58.86	62.53	66.08	69.50	72.76
15.00	52.79	56.32	59.78	63.17	66.49	69.73
20.00	50.65	53.94	57.18	60.37	63.51	66.59
26.00	48.32	51.37	54.39	57.36	60.30	63.19
30.00	46.96	49.80	52.62	55.39	58.13	60.84
40.00	44.08	46.69	49.28	51.85	54.39	56.91
50.00	41.72	44.03	46.34	48.64	50.94	53.23
60.00	53.58	57.41	60.72	63.65	66.28	68.68
70.00	52.55	57.81	62.38	66.37	69.86	72.94
80.00	50.38	55.68	60.48	64.81	68.72	72.22
90.00	48.47	53.53	58.19	62.49	66.42	70.02
100.00	46.84	51.65	56.13	60.27	64.11	67.66
125.00	50.32	55.57	60.14	64.16	67.75	70.98
150.00	47.87	53.53	58.45	62.74	66.51	69.83
200.00	45.03	50.48	55.36	59.71	63.59	67.03
250.00	43.18	48.30	52.97	57.21	61.04	64.50
300.00	41.81	46.68	51.15	55.25	58.99	62.41

Source: DTN: MO0010MWDANS03.005

Table XVII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

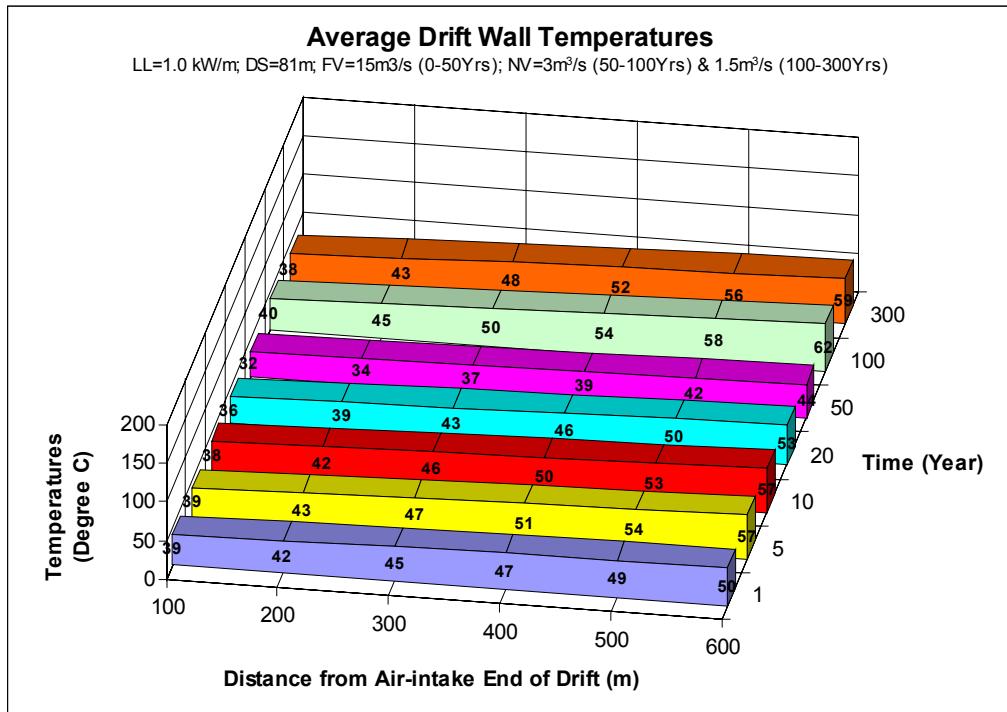
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.76	35.79	35.79	35.79	35.79	35.79
1.00	52.14	43.89	36.72	30.72	25.69	21.48
5.00	67.39	62.74	57.69	52.65	47.75	43.07
10.00	63.00	61.41	59.48	57.22	54.68	51.94
15.00	57.92	56.89	55.78	54.58	53.27	51.81
20.00	53.41	52.58	51.72	50.84	49.92	48.96
26.00	48.88	48.26	47.61	46.95	46.26	45.54
30.00	45.13	44.58	44.05	43.47	42.91	42.31
40.00	40.84	40.52	40.19	39.81	39.40	38.98
50.00	35.57	35.56	35.50	35.41	35.25	35.07
60.00	14.18	12.07	10.46	9.24	8.32	7.61
70.00	19.71	17.01	14.71	12.76	11.13	9.78
80.00	18.94	17.22	15.54	13.95	12.49	11.17
90.00	17.56	16.23	14.95	13.72	12.54	11.45
100.00	16.34	15.21	14.12	13.09	12.11	11.18
125.00	9.85	8.45	7.35	6.48	5.77	5.18
150.00	10.45	9.01	7.79	6.77	5.91	5.20
200.00	9.41	8.45	7.54	6.70	5.94	5.27
250.00	8.44	7.74	7.05	6.40	5.78	5.20
300.00	7.77	7.19	6.62	6.07	5.55	5.06

Source: DTN: MO0010MWDANS03.005

Table XVII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

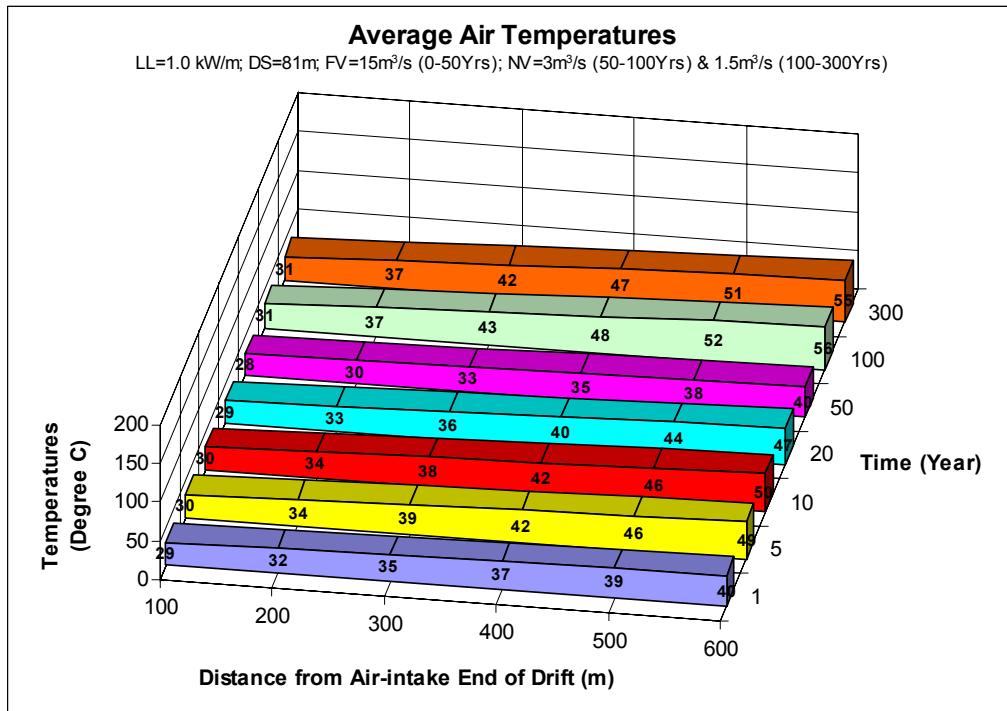
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	600.00	600.00	1.89	1.0E-4	214.72	107.36	0.34				
1.00	96.99%	581.96	590.98	18635.31	1.00	210.64	212.68	6706.45				
5.00	87.93%	527.56	554.76	69979.72	5.00	331.30	270.97	34181.26				
10.00	79.35%	476.12	501.84	79129.84	10.00	347.72	339.51	53534.15				
15.00	72.23%	433.40	454.76	71706.06	15.00	330.25	338.98	53451.14				
20.00	66.23%	397.39	415.39	65499.41	20.00	307.43	318.84	50274.84				
26.00	59.89%	359.32	378.36	71591.05	26.00	283.50	295.47	55907.16				
30.00	56.11%	336.67	348.00	43897.73	30.00	262.45	272.98	34434.37				
40.00	48.24%	289.44	313.06	98725.25	40.00	239.74	251.10	79185.74				
50.00	41.94%	251.65	270.54	85318.40	50.00	212.37	226.05	71287.86				
60.00	36.88%	221.25	236.45	74566.81	60.00	61.88	137.12	43242.66				
70.00	32.81%	196.84	209.05	65924.69	70.00	85.10	73.49	23176.08				
80.00	29.47%	176.83	186.83	58920.10	80.00	89.31	87.21	27501.94				
90.00	26.76%	160.58	168.70	53202.00	90.00	86.44	87.88	27713.00				
100.00	24.52%	147.12	153.85	48516.98	100.00	82.06	84.25	26569.12				
125.00	21.21%	127.24	137.18	108151.61	125.00	43.08	62.57	49330.59				
150.00	17.89%	107.37	117.30	92481.71	150.00	45.13	44.11	34774.89				
200.00	14.85%	89.09	98.23	154888.99	200.00	43.30	44.22	69722.60				
250.00	13.03%	78.16	83.63	131862.91	250.00	40.61	41.96	66156.76				
300.00	11.76%	70.58	74.37	117266.25	300.00	38.26	39.44	62185.18				
Total heat generated in 50 years (GJ)				604484.67	Total heat removed in 50 years (GJ)		438963.30					
Total heat generated in 100 years (GJ)				905615.27	Total heat removed in 100 years (GJ)		587166.10					
Total heat generated in 300 years (GJ)				1510266.74	Total heat removed in 300 years (GJ)		869336.13					
Percentage of total heat removal in 50 years = 73%												
Percentage of total heat removal in 100 years = 65%												
Percentage of total heat removal in 300 years = 58%												

Source: DTN: MO0010MWDANS03.005



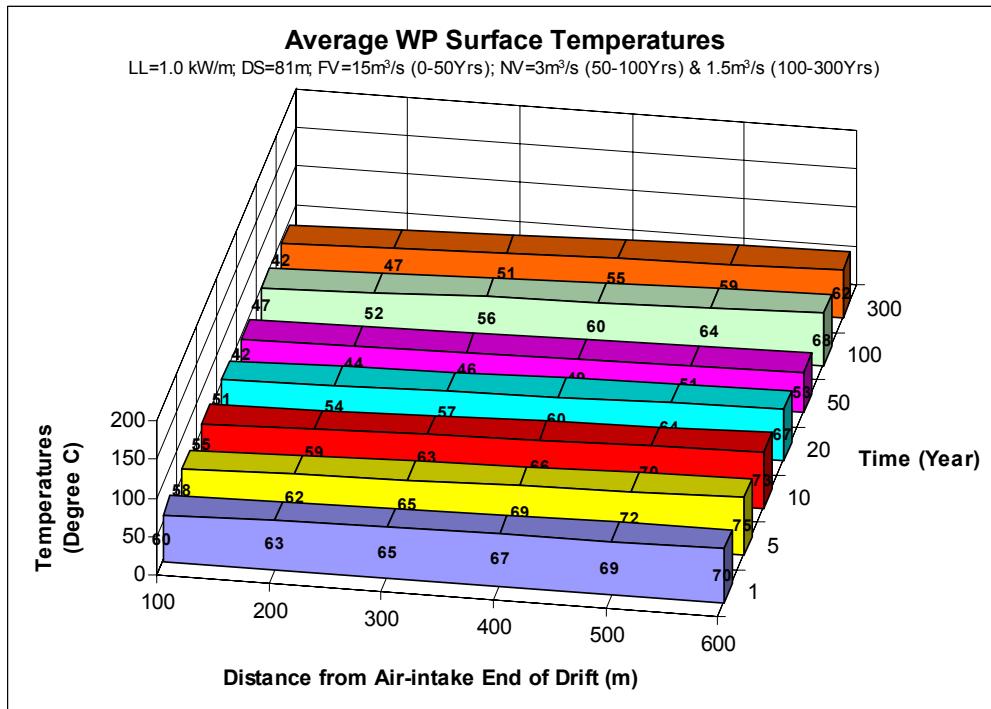
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVII-1, p. XVII-2.

Figure XVII-1. Average Drift Wall Temperatures for Case 16: LF5N3V8



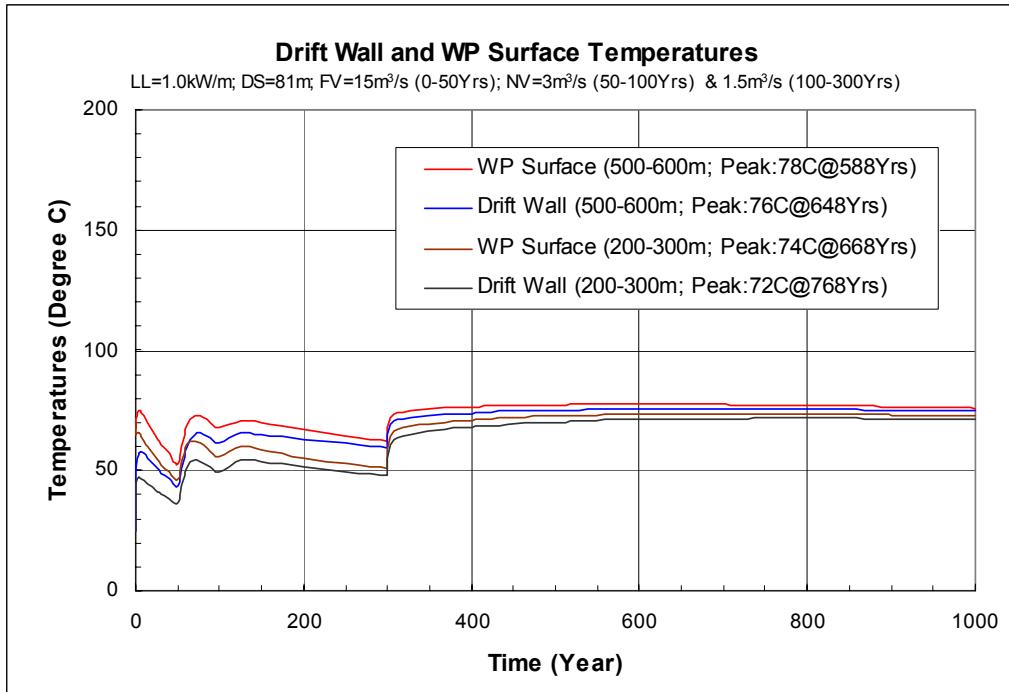
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVII-2, p. XVII-3.

Figure XVII-2. Average Air Temperatures for Case 16: LF5N3V8



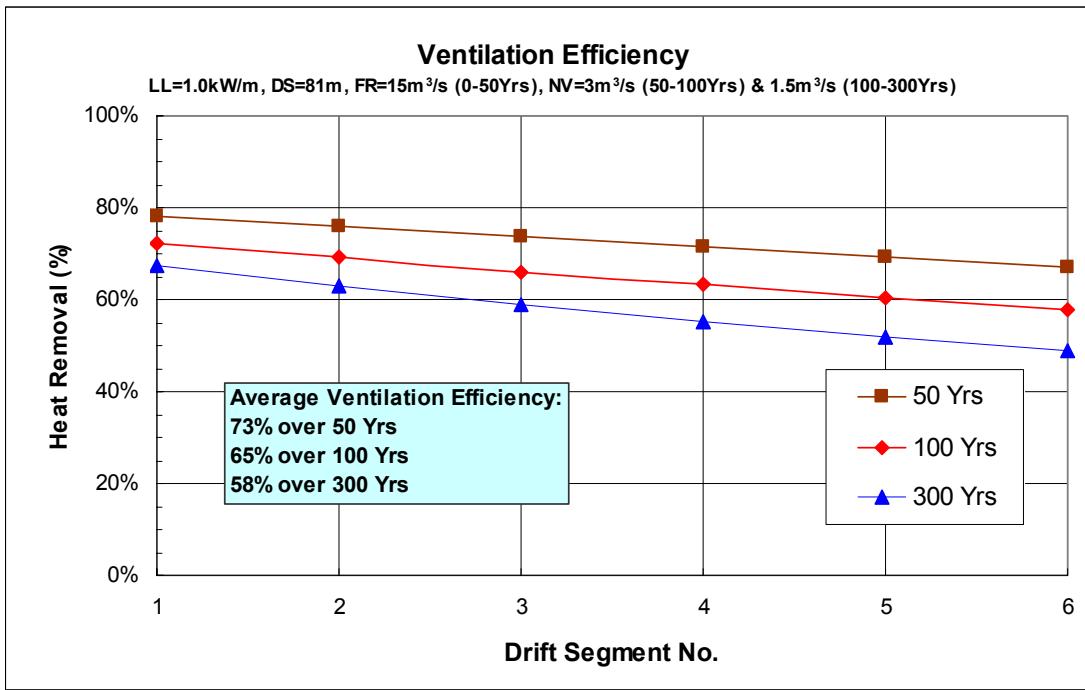
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVII-3, p. XVII-4.

Figure XVII-3. Average Waste Package Surface Temperatures for Case 16: LF5N3V8



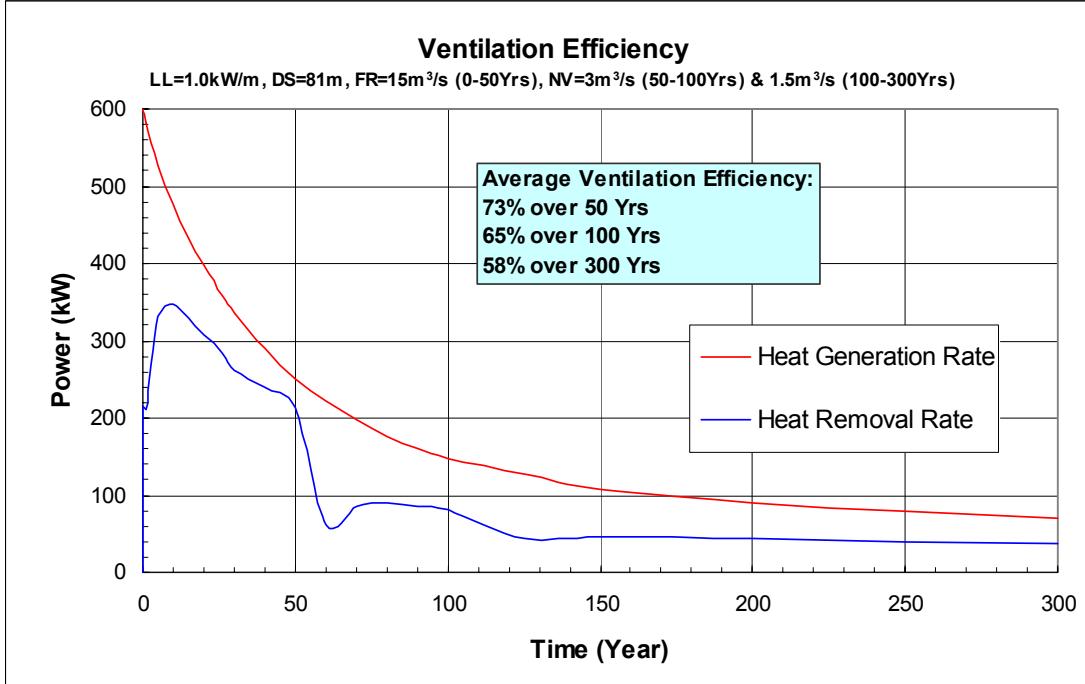
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 16: LF5N3V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVII-5. Average Heat Removal Rates at Different Drift Segments for Case 16: LF5N3V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVII-6. Overall Heat Generation and Removal Rates at Different Time for Case 16: LF5N3V8

ATTACHMENT XVIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 17: LF5N5V8

ATTACHMENT XVIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 17: LF5N5V8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.0 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XVIII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	39.31	42.36	44.80	46.85	48.56	49.98
5.00	38.82	43.10	47.07	50.69	53.99	56.97
10.00	37.69	41.81	45.81	49.67	53.37	56.90
15.00	36.70	40.53	44.29	47.96	51.55	55.04
20.00	35.78	39.33	42.83	46.27	49.63	52.94
26.00	34.77	38.05	41.28	44.46	47.60	50.68
30.00	34.18	37.22	40.23	43.19	46.11	48.99
40.00	32.95	35.72	38.46	41.18	43.86	46.51
50.00	31.96	34.39	36.81	39.23	41.64	44.04
60.00	38.93	42.35	45.46	48.32	50.97	53.48
70.00	38.35	42.57	46.42	49.96	53.19	56.17
80.00	37.25	41.31	45.16	48.79	52.20	55.40
90.00	36.30	40.10	43.73	47.21	50.52	53.69
100.00	35.49	39.04	42.46	45.75	48.91	51.94
125.00	39.28	43.28	46.93	50.25	53.33	56.20
150.00	37.96	42.30	46.25	49.84	53.12	56.13
200.00	36.31	40.37	44.19	47.74	51.05	54.12
250.00	35.23	38.95	42.50	45.86	49.04	52.04
300.00	34.44	37.91	41.23	44.40	47.43	50.30

Source: DTN: MO0010MWDANS03.005

Table XVIII-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	28.77	31.94	34.60	36.82	38.67	40.23
5.00	29.87	34.41	38.58	42.38	45.83	48.95
10.00	29.55	33.99	38.29	42.43	46.38	50.13
15.00	29.19	33.30	37.33	41.28	45.13	48.87
20.00	28.86	32.66	36.40	40.07	43.68	47.22
26.00	28.53	32.02	35.46	38.86	42.20	45.49
30.00	28.26	31.49	34.67	37.81	40.91	43.97
40.00	27.95	30.88	33.79	36.66	39.51	42.33
50.00	27.57	30.14	32.71	35.27	37.82	40.35
60.00	29.16	32.90	36.31	39.45	42.39	45.15
70.00	30.17	34.88	39.18	43.10	46.69	49.99
80.00	29.82	34.41	38.74	42.82	46.64	50.21
90.00	29.43	33.68	37.76	41.65	45.37	48.89
100.00	29.09	33.04	36.84	40.50	44.01	47.37
125.00	30.17	34.82	39.03	42.90	46.48	49.81
150.00	30.58	35.62	40.18	44.33	48.10	51.55
200.00	29.95	34.61	38.97	43.03	46.79	50.28
250.00	29.38	33.57	37.56	41.35	44.93	48.30
300.00	28.99	32.83	36.51	40.03	43.39	46.59

Source: DTN: MO0010MWDANS03.005

Table XVIII-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	67.93	67.95	67.95	67.95	67.95	67.95
1.00	60.29	63.08	65.36	67.26	68.85	70.18
5.00	57.91	61.82	65.45	68.78	71.82	74.57
10.00	55.09	58.86	62.53	66.08	69.50	72.76
15.00	52.79	56.32	59.78	63.17	66.49	69.73
20.00	50.65	53.94	57.18	60.37	63.51	66.59
26.00	48.32	51.37	54.39	57.36	60.30	63.19
30.00	46.96	49.80	52.62	55.39	58.13	60.84
40.00	44.08	46.69	49.28	51.85	54.39	56.91
50.00	41.72	44.03	46.34	48.64	50.94	53.23
60.00	48.58	51.84	54.80	57.52	60.05	62.44
70.00	46.92	50.98	54.69	58.09	61.20	64.07
80.00	45.01	48.92	52.63	56.14	59.44	62.53
90.00	43.38	47.05	50.56	53.93	57.14	60.21
100.00	42.01	45.45	48.77	51.96	55.03	57.97
125.00	45.20	49.10	52.64	55.88	58.87	61.66
150.00	42.97	47.23	51.09	54.61	57.83	60.77
200.00	40.50	44.49	48.23	51.73	54.99	58.00
250.00	38.92	42.58	46.07	49.38	52.51	55.46
300.00	37.78	41.19	44.46	47.59	50.57	53.41

Source: DTN: MO0010MWDANS03.005

Table XVIII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

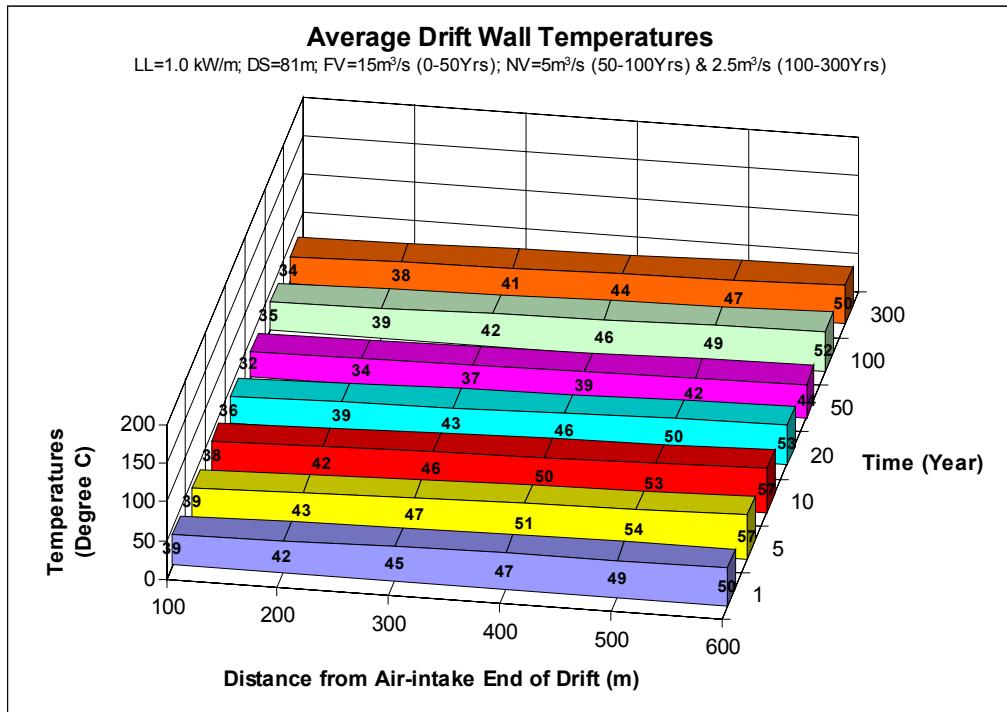
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.76	35.79	35.79	35.79	35.79	35.79
1.00	52.14	43.89	36.72	30.72	25.69	21.48
5.00	67.39	62.74	57.69	52.65	47.75	43.07
10.00	63.00	61.41	59.48	57.22	54.68	51.94
15.00	57.92	56.89	55.78	54.58	53.27	51.81
20.00	53.41	52.58	51.72	50.84	49.92	48.96
26.00	48.88	48.26	47.61	46.95	46.26	45.54
30.00	45.13	44.58	44.05	43.47	42.91	42.31
40.00	40.84	40.52	40.19	39.81	39.40	38.98
50.00	35.57	35.56	35.50	35.41	35.25	35.07
60.00	18.43	16.58	15.12	13.95	13.01	12.27
70.00	22.92	20.89	19.04	17.39	15.92	14.64
80.00	21.39	20.33	19.21	18.07	16.93	15.83
90.00	19.64	18.86	18.07	17.27	16.46	15.65
100.00	18.15	17.50	16.85	16.21	15.56	14.93
125.00	11.16	10.01	9.09	8.34	7.72	7.19
150.00	12.02	10.87	9.84	8.93	8.14	7.45
200.00	10.67	10.05	9.40	8.75	8.12	7.52
250.00	9.44	9.04	8.61	8.17	7.72	7.26
300.00	8.60	8.27	7.94	7.59	7.24	6.89

Source: DTN: MO0010MWDANS03.005

Table XVIII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m)

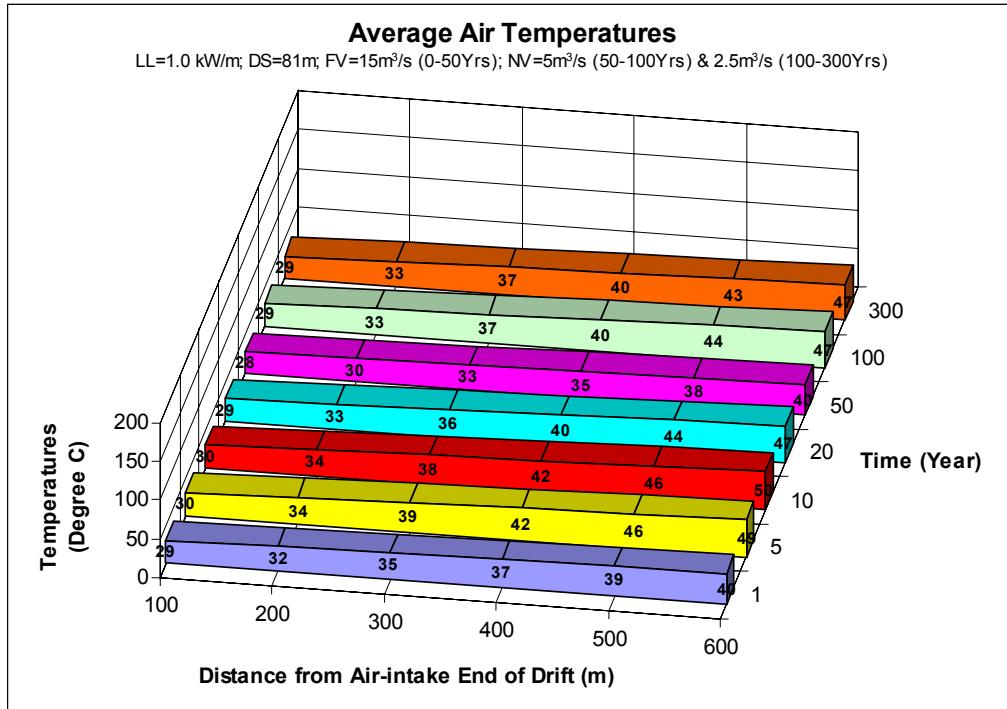
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	600.00	600.00	1.89	1.0E-4	214.72	107.36	0.34				
1.00	96.99%	581.96	590.98	18635.31	1.00	210.64	212.68	6706.45				
5.00	87.93%	527.56	554.76	69979.72	5.00	331.30	270.97	34181.26				
10.00	79.35%	476.12	501.84	79129.84	10.00	347.72	339.51	53534.15				
15.00	72.23%	433.40	454.76	71706.06	15.00	330.25	338.98	53451.14				
20.00	66.23%	397.39	415.39	65499.41	20.00	307.43	318.84	50274.84				
26.00	59.89%	359.32	378.36	71591.05	26.00	283.50	295.47	55907.16				
30.00	56.11%	336.67	348.00	43897.73	30.00	262.45	272.98	34434.37				
40.00	48.24%	289.44	313.06	98725.25	40.00	239.74	251.10	79185.74				
50.00	41.94%	251.65	270.54	85318.40	50.00	212.37	226.05	71287.86				
60.00	36.88%	221.25	236.45	74566.81	60.00	89.36	150.86	47576.54				
70.00	32.81%	196.84	209.05	65924.69	70.00	110.81	100.09	31563.33				
80.00	29.47%	176.83	186.83	58920.10	80.00	111.77	111.29	35095.73				
90.00	26.76%	160.58	168.70	53202.00	90.00	105.95	108.86	34328.92				
100.00	24.52%	147.12	153.85	48516.98	100.00	99.20	102.57	32347.29				
125.00	21.21%	127.24	137.18	108151.61	125.00	53.49	76.35	60191.28				
150.00	17.89%	107.37	117.30	92481.71	150.00	57.25	55.37	43655.42				
200.00	14.85%	89.09	98.23	154888.99	200.00	59.83	58.54	92307.14				
250.00	13.03%	78.16	83.63	131862.91	250.00	50.23	55.03	86774.79				
300.00	11.76%	70.58	74.37	117266.25	300.00	46.55	48.39	76301.50				
Total heat generated in 50 years (GJ)				604484.67	Total heat removed in 50 years (GJ)		438963.30					
Total heat generated in 100 years (GJ)				905615.27	Total heat removed in 100 years (GJ)		619875.11					
Total heat generated in 300 years (GJ)				1510266.74	Total heat removed in 300 years (GJ)		979105.26					
Percentage of total heat removal in 50 years = 73%												
Percentage of total heat removal in 100 years = 68%												
Percentage of total heat removal in 300 years = 65%												

Source: DTN: MO0010MWDANS03.005



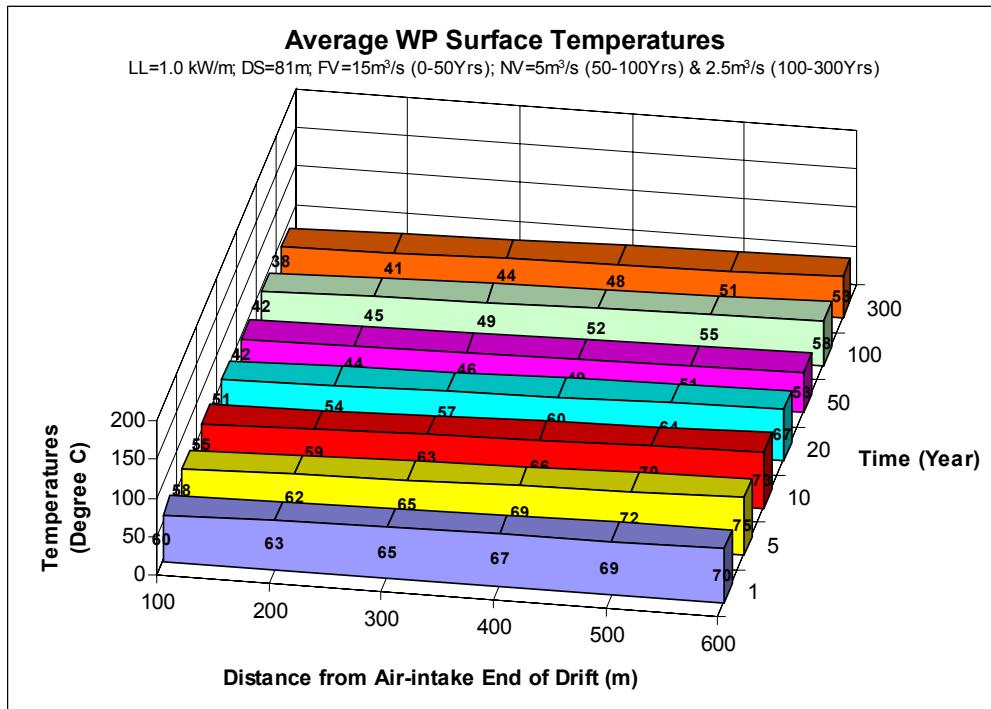
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVIII-1, p. XVIII-2.

Figure XVIII-1. Average Drift Wall Temperatures for Case 17: LF5N5V8



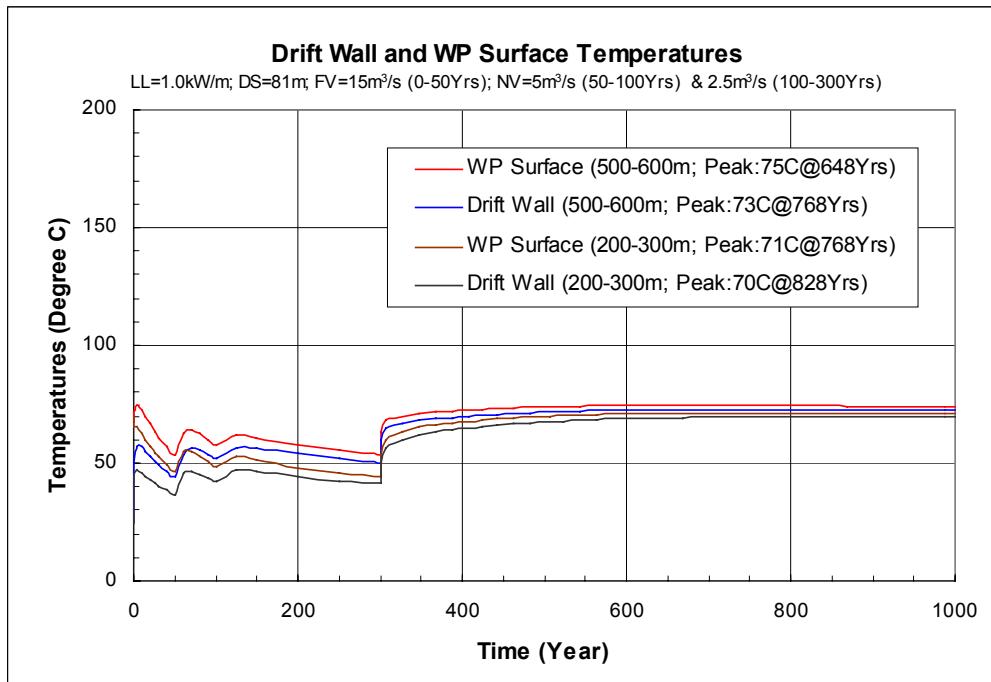
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVIII-2, p. XVIII-3.

Figure XVIII-2. Average Air Temperatures for Case 17: LF5N5V8



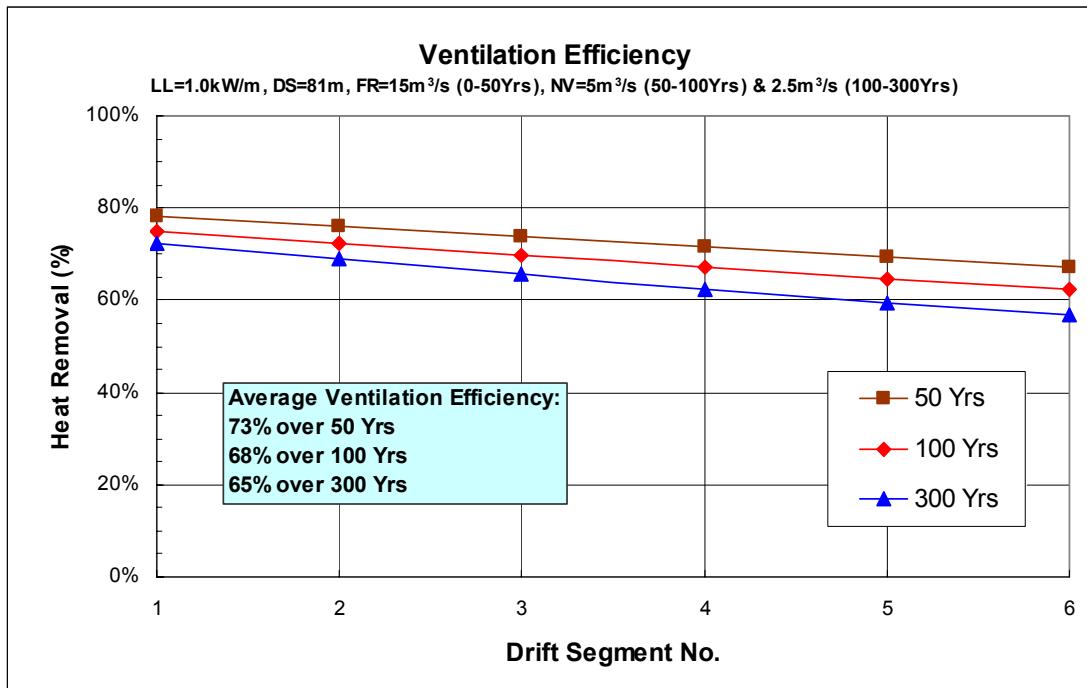
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XVIII-3, p. XVIII-4.

Figure XVIII-3. Average Waste Package Surface Temperatures for Case 17: LF5N5V8



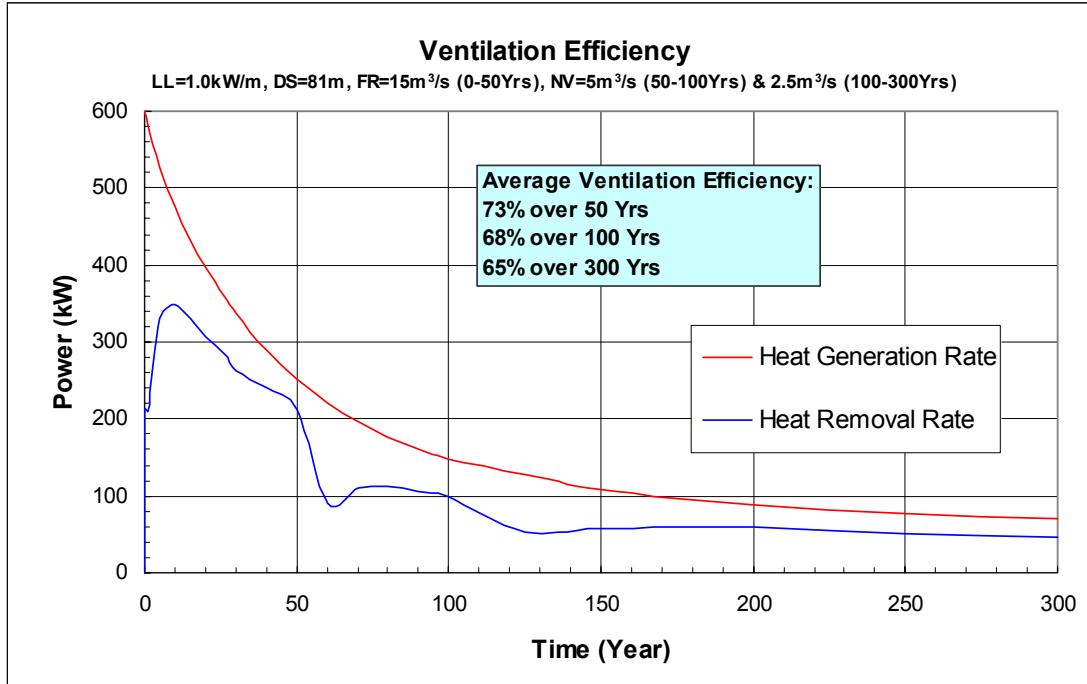
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVIII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 17: LF5N5V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVIII-5. Average Heat Removal Rates at Different Drift Segments for Case 17: LF5N5V8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XVIII-6. Overall Heat Generation and Removal Rates at Different Time for Case 17: LF5N5V8

ATTACHMENT XIX

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 18: HF5N5V4

ATTACHMENT XIX

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 18: HF5N5V4

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Drift spacing for this case is reduced to 40.5 m. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XIX-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	46.13	50.11	53.30	55.96	58.20	60.06
5.00	45.52	51.76	57.48	62.68	67.37	71.61
10.00	44.03	50.16	56.09	61.79	67.24	72.42
15.00	42.57	48.33	53.99	59.52	64.91	70.16
20.00	41.30	46.70	52.02	57.26	62.40	67.46
26.00	39.89	44.92	49.88	54.80	59.66	64.44
30.00	39.01	43.71	48.37	52.99	57.56	62.09
40.00	37.14	41.42	45.69	49.95	54.18	58.40
50.00	35.60	39.37	43.17	46.98	50.80	54.62
60.00	46.13	51.50	56.44	61.04	65.38	69.51
70.00	45.53	52.19	58.34	64.03	69.33	74.26
80.00	44.02	50.55	56.80	62.75	68.40	73.77
90.00	42.63	48.82	54.82	60.62	66.22	71.61
100.00	41.41	47.24	52.94	58.49	63.90	69.14
125.00	47.44	54.17	60.40	66.22	71.71	76.91
150.00	45.73	53.11	59.96	66.32	72.25	77.81
200.00	43.03	50.02	56.74	63.16	69.25	75.03
250.00	41.17	47.55	53.79	59.87	65.76	71.44
300.00	39.81	45.68	51.47	57.15	62.72	68.16

Source: DTN: MO0010MWDANS03.005

Table XIX-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.89	34.00	37.43	40.31	42.71	44.72
5.00	32.06	38.57	44.51	49.89	54.75	59.11
10.00	31.65	38.13	44.39	50.41	56.14	61.57
15.00	31.14	37.19	43.13	48.95	54.63	60.16
20.00	30.68	36.30	41.85	47.32	52.71	58.00
26.00	30.24	35.43	40.58	45.69	50.73	55.72
30.00	29.86	34.69	39.48	44.24	48.97	53.65
40.00	29.40	33.80	38.19	42.57	46.94	51.28
50.00	28.83	32.70	36.59	40.50	44.42	48.35
60.00	31.21	36.85	42.04	46.89	51.46	55.81
70.00	32.77	39.93	46.53	52.63	58.28	63.54
80.00	32.33	39.38	46.13	52.54	58.63	64.38
90.00	31.78	38.39	44.82	51.04	57.04	62.82
100.00	31.29	37.46	43.50	49.41	55.15	60.74
125.00	33.00	40.33	47.12	53.47	59.46	65.14
150.00	33.72	41.79	49.26	56.19	62.65	68.68
200.00	32.80	40.34	47.58	54.48	61.03	67.24
250.00	31.87	38.65	45.30	51.78	58.07	64.13
300.00	31.22	37.39	43.48	49.48	55.37	61.12

Source: DTN: MO0010MWDANS03.005

Table XIX-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years)
(Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.04	68.04	68.04	68.04	68.04
1.00	74.51	77.98	80.81	83.18	85.16	86.82
5.00	71.32	76.77	81.80	86.39	90.53	94.30
10.00	67.65	73.01	78.23	83.29	88.15	92.79
15.00	64.35	69.43	74.44	79.37	84.20	88.92
20.00	61.54	66.33	71.07	75.77	80.40	84.97
26.00	58.45	62.95	67.41	71.84	76.24	80.59
30.00	56.56	60.78	64.98	69.16	73.31	77.44
40.00	52.47	56.37	60.27	64.16	68.05	71.93
50.00	49.12	52.58	56.07	59.59	63.12	66.66
60.00	59.11	64.06	68.63	72.89	76.92	80.75
70.00	57.01	63.23	69.00	74.36	79.35	84.00
80.00	54.42	60.54	66.42	72.05	77.40	82.49
90.00	52.18	57.99	63.66	69.16	74.48	79.60
100.00	50.24	55.74	61.13	66.41	71.56	76.56
125.00	55.29	61.70	67.64	73.21	78.46	83.45
150.00	52.36	59.45	66.04	72.18	77.91	83.29
200.00	48.60	55.35	61.84	68.06	73.98	79.60
250.00	46.14	52.29	58.34	64.24	69.97	75.51
300.00	44.33	50.02	55.63	61.16	66.59	71.89

Source: DTN: MO0010MWDANS03.005

Table XIX-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

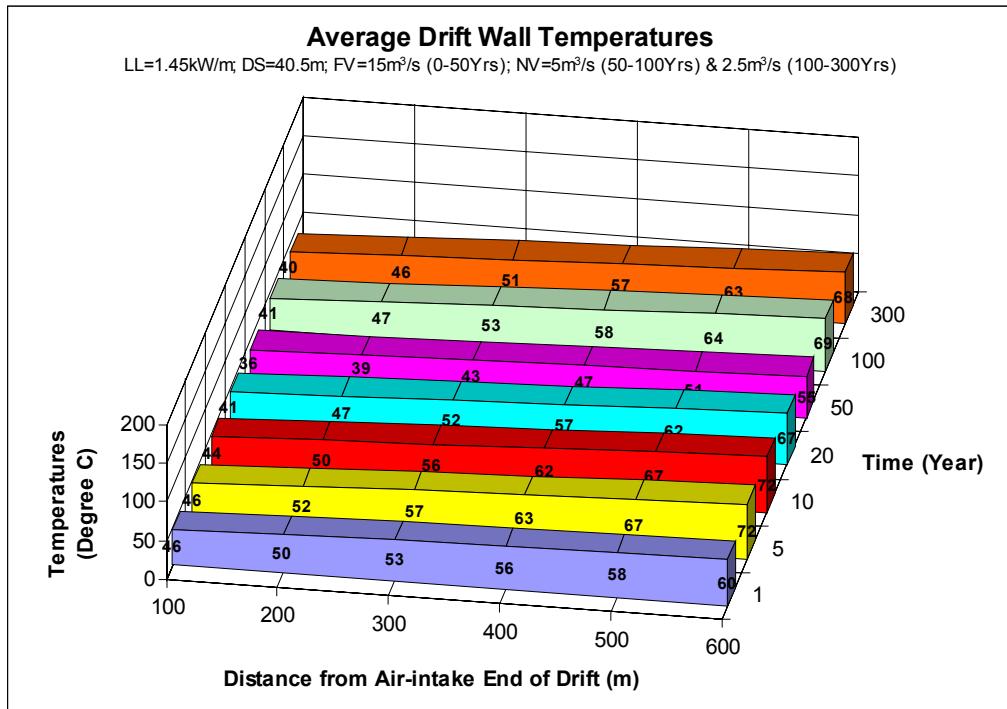
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.83	35.83	35.83	35.83	35.83
1.00	67.59	56.86	47.55	39.76	33.27	27.82
5.00	97.70	90.06	82.16	74.48	67.17	60.31
10.00	91.95	89.64	86.70	83.22	79.33	75.17
15.00	84.96	83.66	82.19	80.50	78.60	76.45
20.00	78.63	77.73	76.76	75.70	74.53	73.26
26.00	72.44	71.89	71.26	70.58	69.83	69.00
30.00	67.19	66.81	66.36	65.87	65.35	64.77
40.00	60.88	60.87	60.77	60.60	60.37	60.11
50.00	53.05	53.47	53.81	54.06	54.24	54.35
60.00	27.52	25.01	23.04	21.48	20.27	19.30
70.00	34.46	31.75	29.26	27.03	25.06	23.32
80.00	32.49	31.28	29.91	28.45	26.97	25.51
90.00	30.06	29.32	28.48	27.59	26.62	25.62
100.00	27.90	27.37	26.79	26.16	25.49	24.78
125.00	17.25	15.79	14.64	13.70	12.92	12.25
150.00	18.80	17.40	16.11	14.95	13.92	13.01
200.00	16.81	16.27	15.61	14.88	14.13	13.38
250.00	14.81	14.62	14.34	13.98	13.55	13.07
300.00	13.41	13.30	13.14	12.94	12.69	12.40

Source: DTN: MO0010MWDANS03.005

Table XIX-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

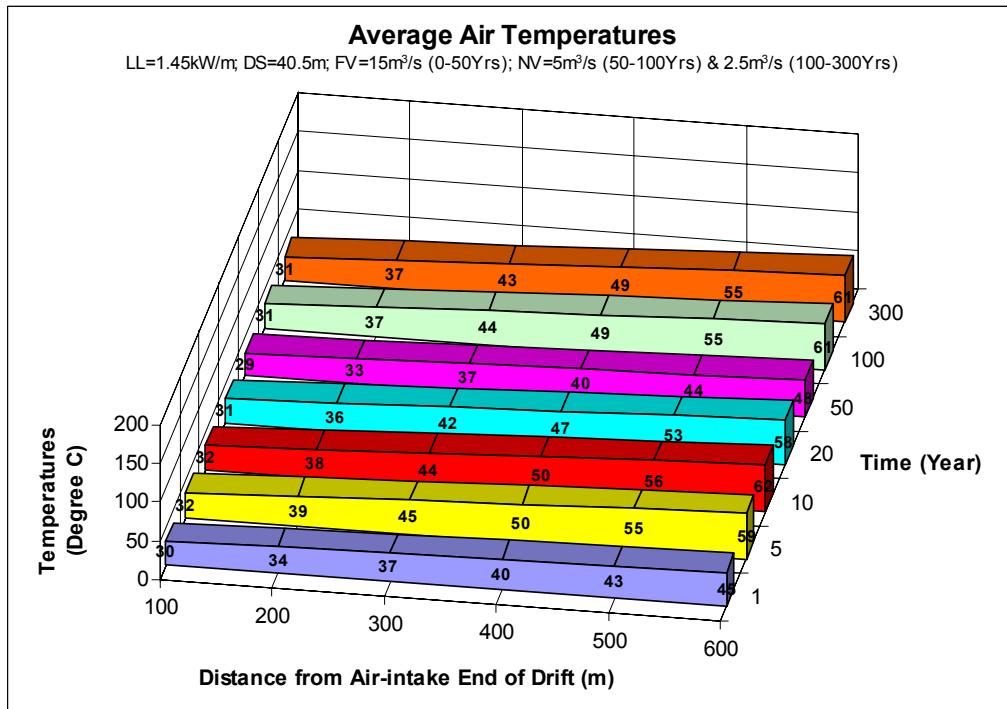
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.96	107.48	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	272.85	243.90	7690.95				
5.00	87.93%	764.96	804.40	101470.60	5.00	471.88	372.36	46971.24				
10.00	79.35%	690.37	727.67	114738.26	10.00	505.99	488.93	77095.25				
15.00	72.23%	628.43	659.40	103973.79	15.00	486.37	496.18	78237.66				
20.00	66.23%	576.22	602.32	94974.15	20.00	456.61	471.49	74343.89				
26.00	59.89%	521.01	548.62	103807.02	26.00	425.01	440.81	83407.56				
30.00	56.11%	488.18	504.60	63651.70	30.00	396.36	410.68	51805.28				
40.00	48.24%	419.68	453.93	143151.62	40.00	363.59	379.98	119829.88				
50.00	41.94%	364.89	392.29	123711.69	50.00	322.98	343.29	108259.47				
60.00	36.88%	320.81	342.85	108121.88	60.00	136.61	229.80	72468.82				
70.00	32.81%	285.42	303.12	95590.81	70.00	170.87	153.74	48483.30				
80.00	29.47%	256.40	270.91	85434.15	80.00	174.62	172.74	54476.24				
90.00	26.76%	232.84	244.62	77142.91	90.00	167.68	171.15	53974.33				
100.00	24.52%	213.32	223.08	70349.62	100.00	158.48	163.08	51429.87				
125.00	21.21%	184.50	198.91	156819.84	125.00	86.55	122.51	96590.00				
150.00	17.89%	155.68	170.09	134098.48	150.00	94.18	90.36	71240.69				
200.00	14.85%	129.19	142.43	224589.03	200.00	91.07	92.62	146044.54				
250.00	13.03%	113.33	121.26	191201.22	250.00	84.37	87.72	138311.46				
300.00	11.76%	102.34	107.84	170036.07	300.00	77.88	81.12	127912.68				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		647641.52					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		928474.08					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1508573.45					
Percentage of total heat removal in 50 years = 74%												
Percentage of total heat removal in 100 years = 71%												
Percentage of total heat removal in 300 years = 69%												

Source: DTN: MO0010MWDANS03.005



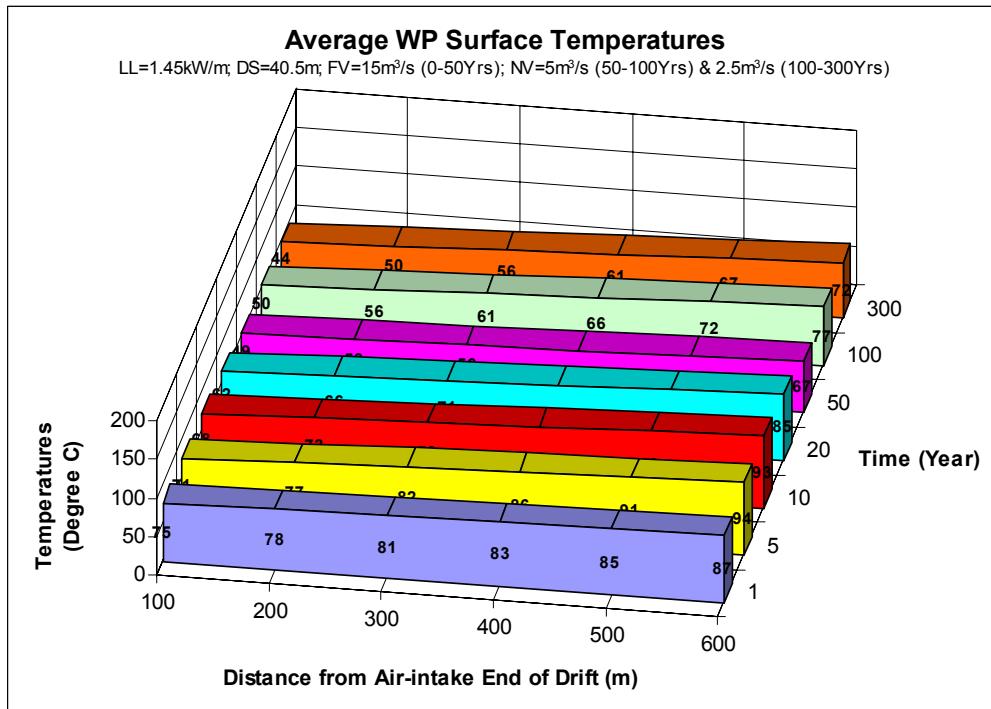
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XIX-1, p. XIX-2.

Figure XIX-1. Average Drift Wall Temperatures for Case 18: HF5N5V4



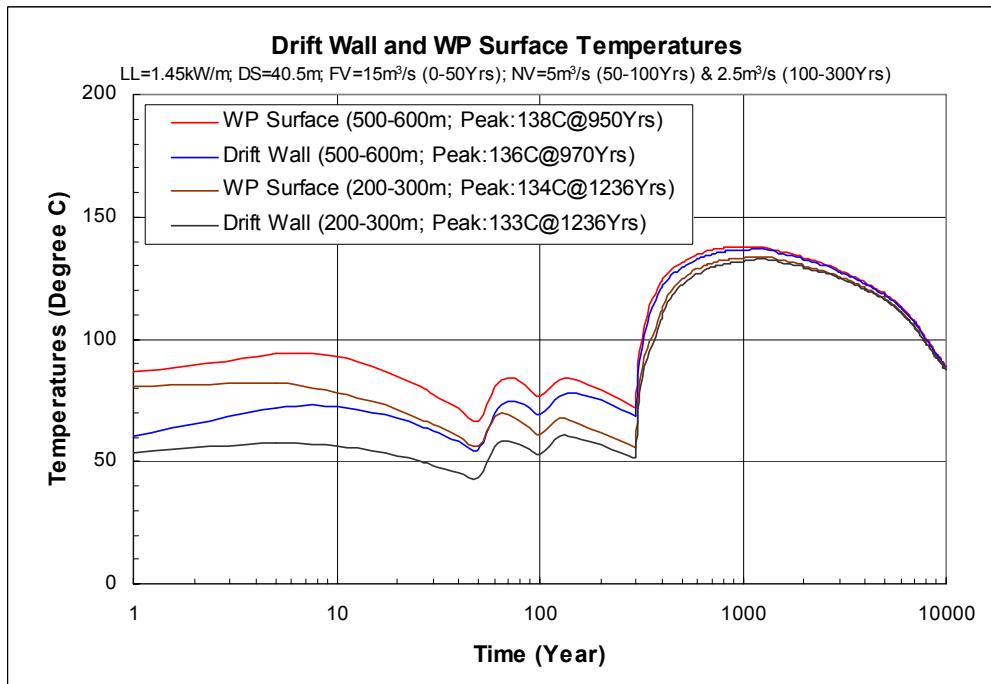
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XIX-2, p. XIX-3.

Figure XIX-2. Average Air Temperatures for Case 18: HF5N5V4



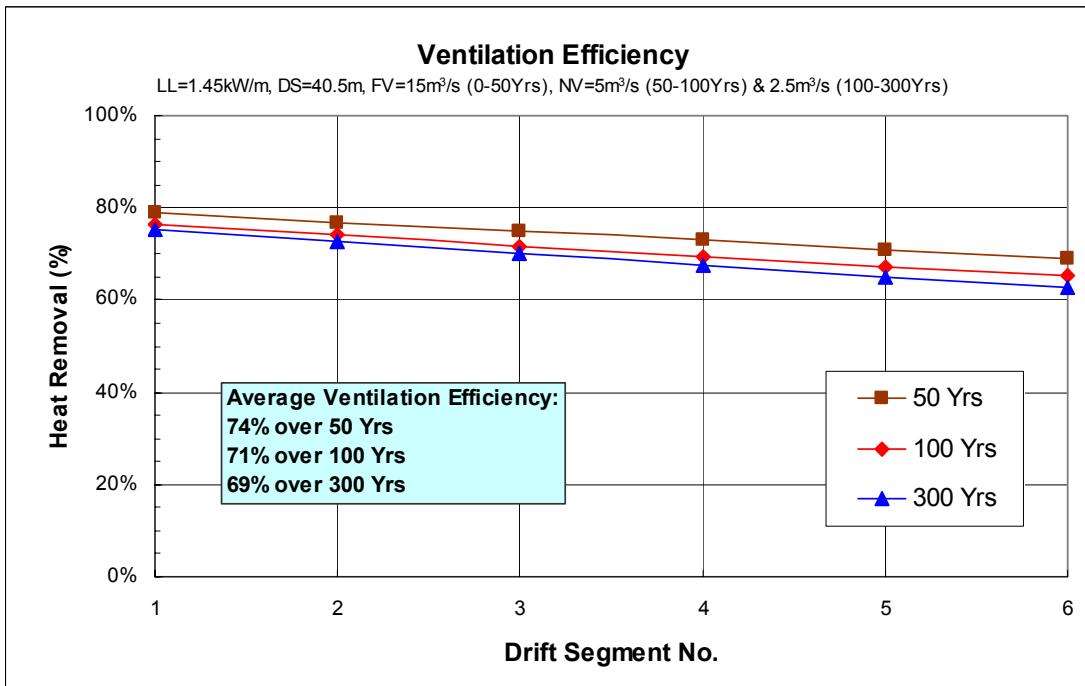
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XIX-3, p. XIX-4.

Figure XIX-3. Average Waste Package Surface Temperatures for Case 18: HF5N5V4



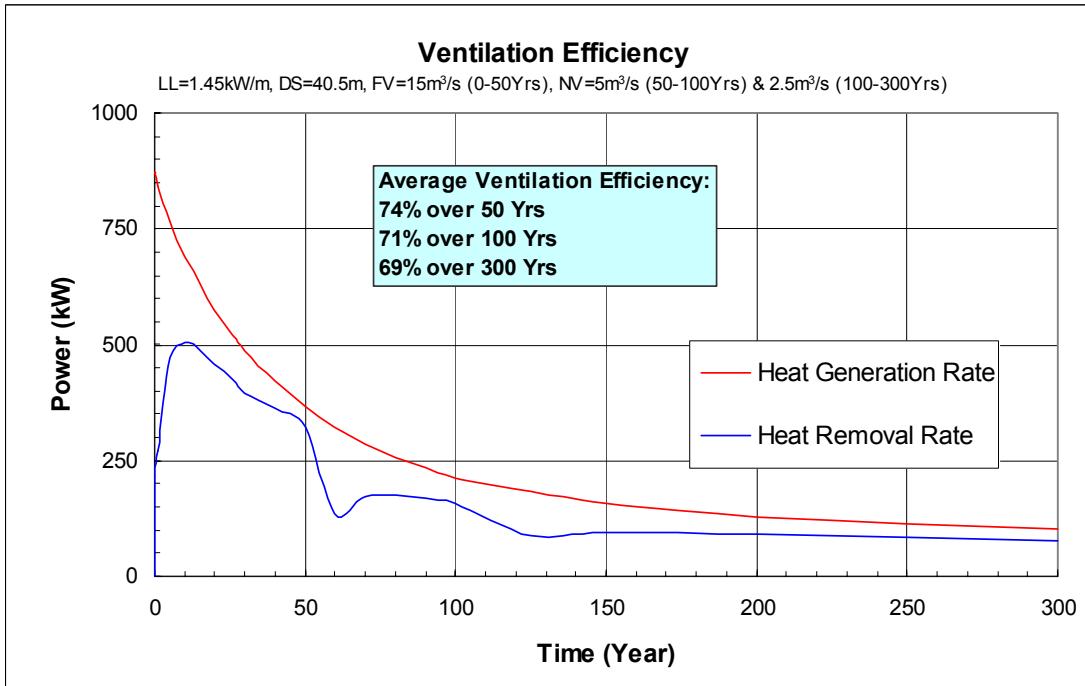
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIX-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 18: HF5N5V4



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIX-5. Average Heat Removal Rates at Different Drift Segments for Case 18: HF5N5V4



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XIX-6. Overall Heat Generation and Removal Rates at Different Time for Case 18: HF5N5V4

ATTACHMENT XX

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 19: LF5N3V4

ATTACHMENT XX

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 19: LF5N3V4

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.0 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 3 m³/s from 50 to 100 years and 1.5 m³/s from 100 to 300 years. Drift spacing for this case is 40.5 m. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XX-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	39.31	42.36	44.81	46.85	48.56	49.98
5.00	38.88	43.17	47.14	50.78	54.10	57.09
10.00	37.86	42.05	46.12	50.04	53.80	57.38
15.00	36.95	40.90	44.77	48.57	52.27	55.89
20.00	36.07	39.78	43.43	47.03	50.57	54.04
26.00	35.09	38.53	41.93	45.30	48.63	51.93
30.00	34.50	37.71	40.90	44.05	47.19	50.29
40.00	33.25	36.19	39.10	42.02	44.92	47.81
50.00	32.23	34.81	37.41	40.02	42.63	45.25
60.00	44.39	48.75	52.59	56.04	59.19	62.11
70.00	45.05	51.04	56.31	60.98	65.14	68.86
80.00	43.96	50.17	55.86	61.06	65.79	70.09
90.00	42.79	48.84	54.51	59.79	64.69	69.23
100.00	41.70	47.53	53.03	58.23	63.12	67.70
125.00	46.51	53.06	58.92	64.23	69.08	73.54
150.00	45.27	52.42	58.82	64.56	69.74	74.44
200.00	43.00	50.01	56.49	62.45	67.90	72.89
250.00	41.32	47.89	54.11	59.96	65.42	70.50
300.00	40.05	46.20	52.10	57.73	63.06	68.09

Source: DTN: MO0010MWDANS03.005

Table XX-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m^3/s (0-50 Years), 3 m^3/s (50-100 Years), and 1.5 m^3/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	28.77	31.94	34.60	36.82	38.67	40.23
5.00	29.88	34.42	38.60	42.41	45.87	48.99
10.00	29.58	34.05	38.38	42.55	46.54	50.33
15.00	29.24	33.41	37.51	41.53	45.46	49.28
20.00	28.93	32.81	36.65	40.43	44.15	47.81
26.00	28.61	32.19	35.74	39.26	42.75	46.19
30.00	28.34	31.66	34.96	38.24	41.49	44.72
40.00	28.03	31.05	34.08	37.09	40.10	43.09
50.00	27.64	30.30	32.98	35.67	38.37	41.08
60.00	30.60	35.41	39.63	43.41	46.85	50.04
70.00	32.87	39.75	45.77	51.07	55.75	59.93
80.00	32.71	39.82	46.32	52.24	57.61	62.48
90.00	32.24	39.06	45.45	51.41	56.94	62.06
100.00	31.78	38.24	44.37	50.16	55.61	60.73
125.00	33.55	41.09	47.83	53.94	59.52	64.64
150.00	34.22	42.43	49.75	56.31	62.21	67.55
200.00	33.40	41.24	48.48	55.12	61.20	66.76
250.00	32.52	39.72	46.56	52.99	59.01	64.60
300.00	31.87	38.51	44.90	51.01	56.81	62.29

Source: DTN: MO0010MWDANS03.005

Table XX-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	67.93	67.95	67.95	67.95	67.95	67.95
1.00	60.29	63.08	65.36	67.27	68.86	70.18
5.00	57.95	61.87	65.50	68.84	71.90	74.66
10.00	55.21	59.03	62.75	66.36	69.82	73.14
15.00	52.96	56.58	60.13	63.63	67.05	70.40
20.00	50.85	54.26	57.63	60.96	64.24	67.47
26.00	48.54	51.72	54.88	58.01	61.12	64.19
30.00	47.17	50.15	53.12	56.06	58.99	61.89
40.00	44.28	47.03	49.77	52.51	55.24	57.96
50.00	41.90	44.34	46.79	49.26	51.73	54.22
60.00	54.15	58.28	61.91	65.17	68.15	70.91
70.00	53.54	59.29	64.35	68.83	72.81	76.39
80.00	51.60	57.56	63.04	68.04	72.61	76.77
90.00	49.76	55.58	61.04	66.13	70.88	75.27
100.00	48.12	53.73	59.04	64.07	68.80	73.25
125.00	52.22	58.56	64.24	69.39	74.10	78.43
150.00	50.06	57.03	63.28	68.88	73.95	78.54
200.00	47.01	53.86	60.20	66.04	71.39	76.29
250.00	44.87	51.29	57.38	63.13	68.49	73.49
300.00	43.27	49.30	55.08	60.61	65.85	70.80

Source: DTN: MO0010MWDANS03.005

Table XX-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

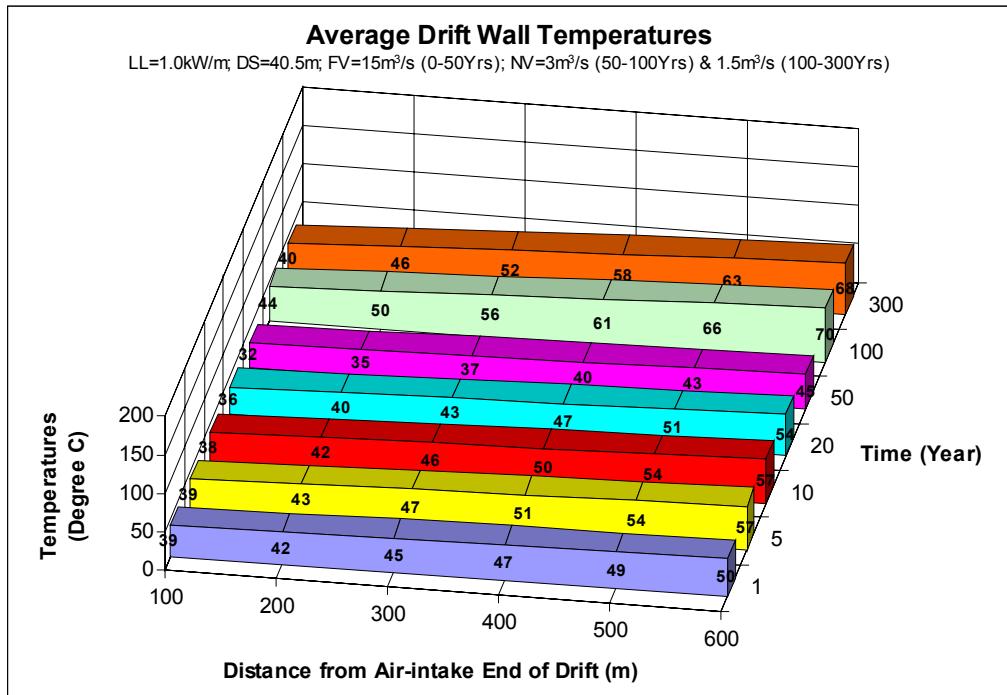
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.76	35.79	35.79	35.79	35.79	35.79
1.00	52.14	43.90	36.72	30.72	25.70	21.48
5.00	67.48	62.84	57.77	52.75	47.85	43.17
10.00	63.38	61.84	59.92	57.67	55.14	52.41
15.00	58.64	57.74	56.73	55.59	54.32	52.91
20.00	54.35	53.73	53.04	52.31	51.51	50.64
26.00	49.92	49.57	49.15	48.70	48.19	47.64
30.00	46.20	45.96	45.67	45.35	45.01	44.64
40.00	41.89	41.88	41.80	41.71	41.56	41.37
50.00	36.54	36.83	37.04	37.23	37.34	37.42
60.00	14.61	12.56	11.02	9.85	8.98	8.31
70.00	20.54	17.95	15.71	13.81	12.23	10.91
80.00	20.12	18.55	16.97	15.44	14.01	12.70
90.00	18.89	17.79	16.67	15.54	14.43	13.36
100.00	17.70	16.85	15.99	15.11	14.23	13.36
125.00	10.77	9.50	8.50	7.70	7.03	6.46
150.00	11.62	10.35	9.23	8.26	7.44	6.73
200.00	10.59	9.87	9.12	8.38	7.66	7.00
250.00	9.48	9.07	8.61	8.11	7.58	7.06
300.00	8.66	8.37	8.05	7.70	7.31	6.91

Source: DTN: MO0010MWDANS03.005

Table XX-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.0 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), and 1.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

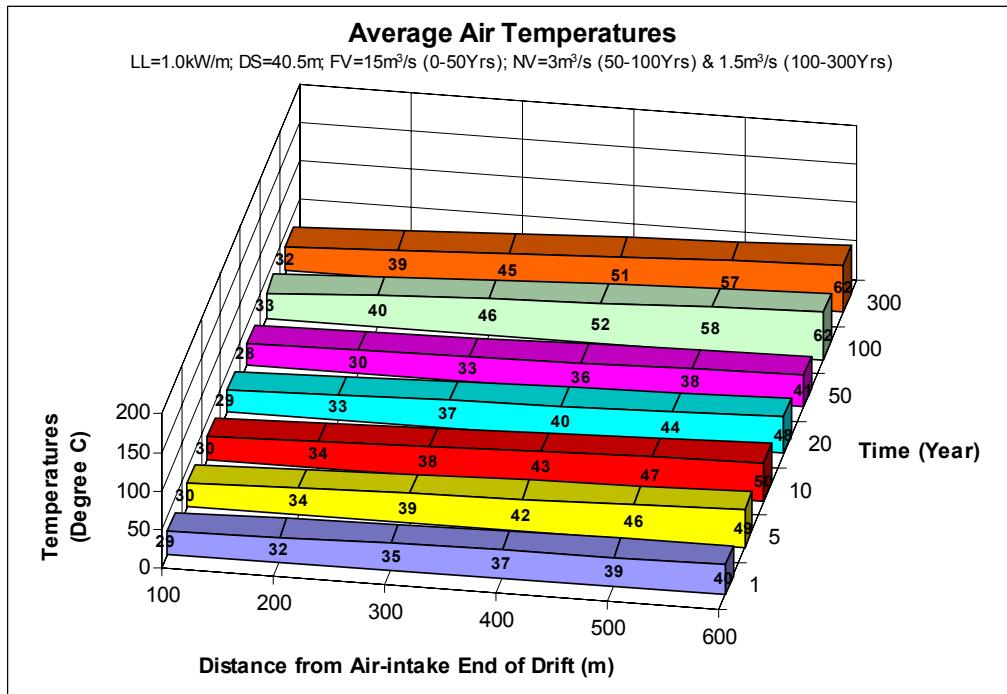
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.0E-4	100.00%	600.00	600.00	1.89	1.0E-4	214.72	107.36	0.34				
1.00	96.99%	581.96	590.98	18635.31	1.00	210.67	212.69	6706.86				
5.00	87.93%	527.56	554.76	69979.72	5.00	331.85	271.26	34217.85				
10.00	79.35%	476.12	501.84	79129.84	10.00	350.37	341.11	53786.26				
15.00	72.23%	433.40	454.76	71706.06	15.00	335.94	343.15	54108.31				
20.00	66.23%	397.39	415.39	65499.41	20.00	315.58	325.76	51365.92				
26.00	59.89%	359.32	378.36	71591.05	26.00	293.18	304.38	57593.51				
30.00	56.11%	336.67	348.00	43897.73	30.00	272.83	283.00	35699.05				
40.00	48.24%	289.44	313.06	98725.25	40.00	250.21	261.52	82472.76				
50.00	41.94%	251.65	270.54	85318.40	50.00	222.42	236.31	74524.24				
60.00	36.88%	221.25	236.45	74566.81	60.00	65.33	143.87	45372.19				
70.00	32.81%	196.84	209.05	65924.69	70.00	91.15	78.24	24673.52				
80.00	29.47%	176.83	186.83	58920.10	80.00	97.79	94.47	29791.86				
90.00	26.76%	160.58	168.70	53202.00	90.00	96.70	97.24	30666.48				
100.00	24.52%	147.12	153.85	48516.98	100.00	93.24	94.97	29949.06				
125.00	21.21%	127.24	137.18	108151.61	125.00	49.96	71.60	56448.30				
150.00	17.89%	107.37	117.30	92481.71	150.00	53.62	51.79	40830.81				
200.00	14.85%	89.09	98.23	154888.99	200.00	52.63	53.12	83766.94				
250.00	13.03%	78.16	83.63	131862.91	250.00	49.91	51.27	80842.75				
300.00	11.76%	70.58	74.37	117266.25	300.00	46.99	48.45	76402.46				
Total heat generated in 50 years (GJ)				604484.67	Total heat removed in 50 years (GJ)		450475.10					
Total heat generated in 100 years (GJ)				905615.27	Total heat removed in 100 years (GJ)		610928.20					
Total heat generated in 300 years (GJ)				1510266.74	Total heat removed in 300 years (GJ)		949219.45					
Percentage of total heat removal in 50 years = 75%												
Percentage of total heat removal in 100 years = 67%												
Percentage of total heat removal in 300 years = 63%												

Source: DTN: MO0010MWDANS03.005



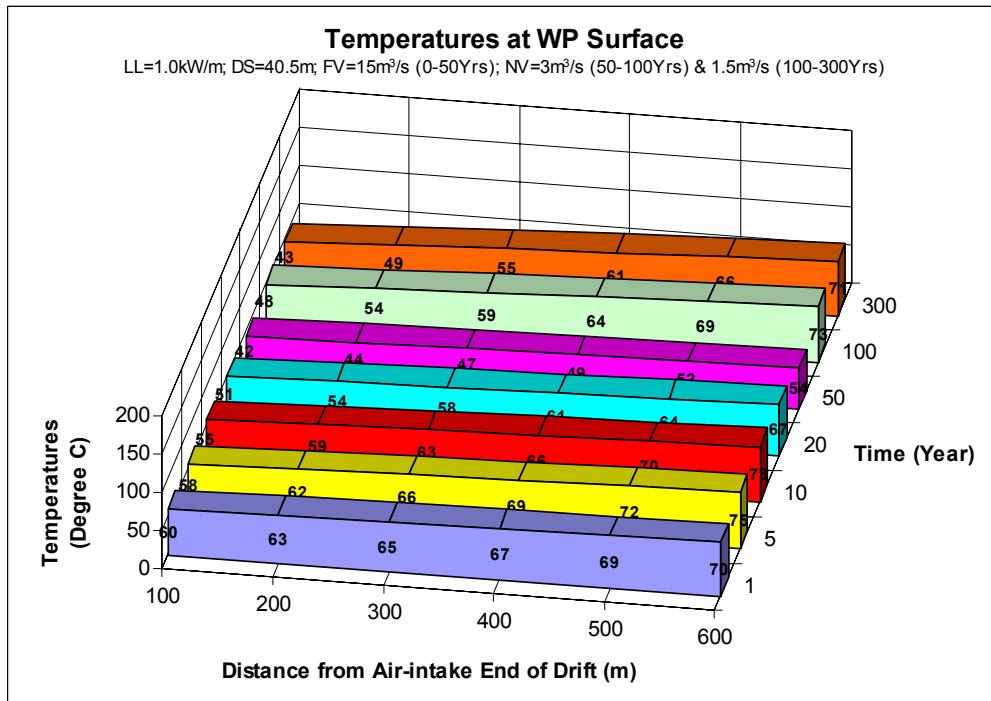
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XX-1, p. XX-2.

Figure XX-1. Average Drift Wall Temperatures for Case 19: LF5N3V4



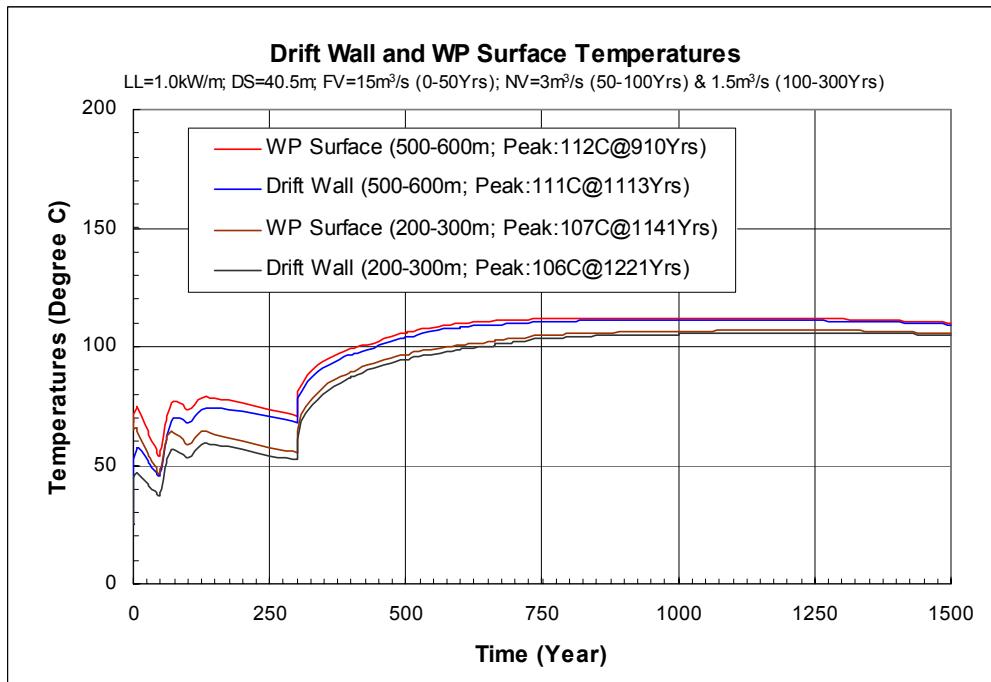
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XX-2, p. XX-3.

Figure XX-2. Average Air Temperatures for Case 19: LF5N3V4



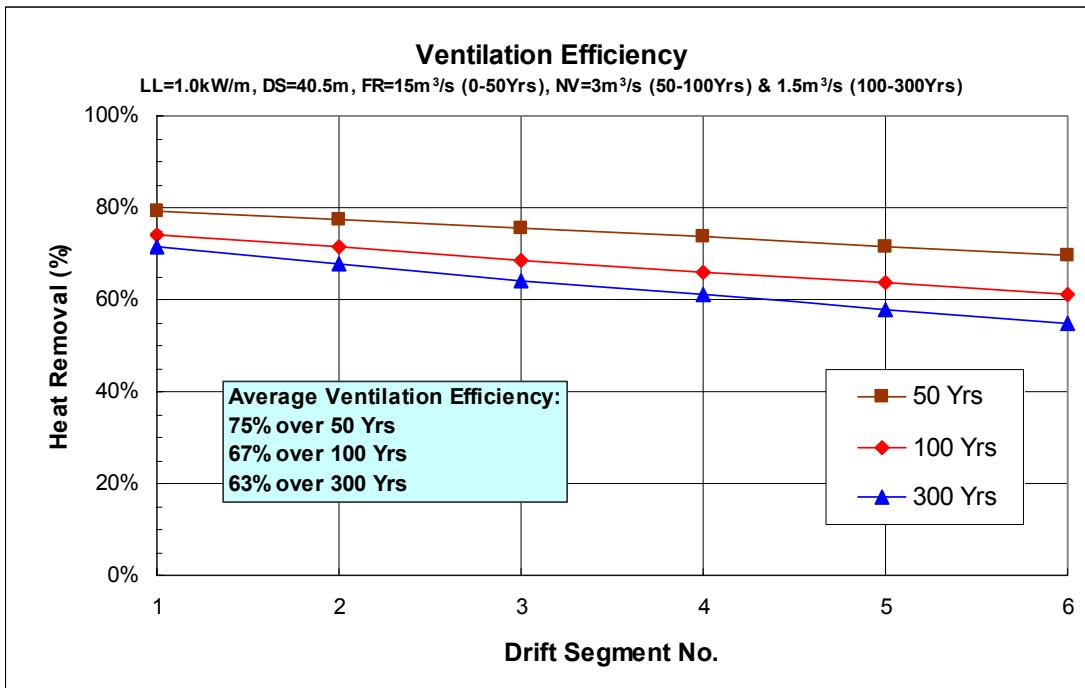
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XX-3, p. XX-4.

Figure XX-3. Average Waste Package Surface Temperatures for Case 19: LF5N3V4



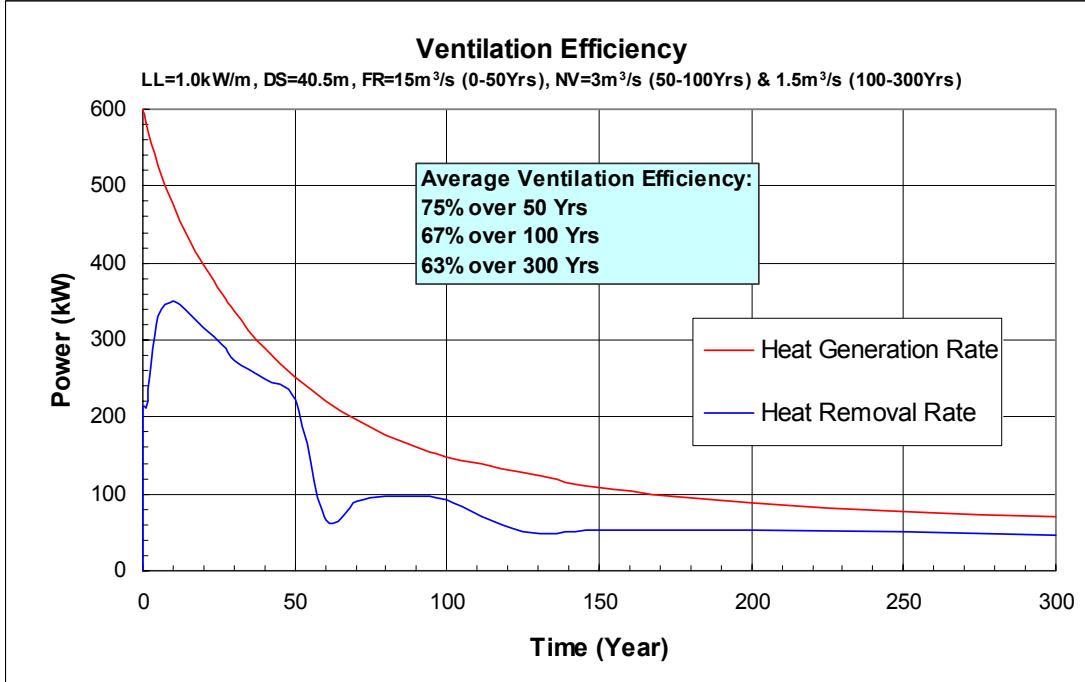
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XX-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 19: LF5N3V4



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XX-5. Average Heat Removal Rates at Different Drift Segments for Case 19: LF5N3V4



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XX-6. Overall Heat Generation and Removal Rates at Different Time for Case 19: LF5N3V4

ATTACHMENT XXI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 20: LF5N5V4

ATTACHMENT XXI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 20: LF5N5V4

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.0 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Drift spacing for this case is 40.5 m. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XXI-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	39.31	42.36	44.81	46.85	48.56	49.98
5.00	38.88	43.17	47.14	50.78	54.10	57.09
10.00	37.86	42.05	46.12	50.04	53.80	57.38
15.00	36.95	40.90	44.77	48.57	52.27	55.89
20.00	36.07	39.78	43.43	47.03	50.57	54.04
26.00	35.09	38.53	41.93	45.30	48.63	51.93
30.00	34.50	37.71	40.90	44.05	47.19	50.29
40.00	33.25	36.19	39.10	42.02	44.92	47.81
50.00	32.23	34.81	37.41	40.02	42.63	45.25
60.00	39.43	43.12	46.51	49.66	52.64	55.46
70.00	39.05	43.62	47.84	51.76	55.39	58.78
80.00	38.03	42.52	46.81	50.90	54.79	58.47
90.00	37.07	41.33	45.45	49.43	53.28	56.99
100.00	36.23	40.23	44.15	47.96	51.67	55.27
125.00	40.38	45.00	49.28	53.28	57.05	60.63
150.00	39.24	44.31	49.01	53.09	57.43	61.26
200.00	37.41	42.22	46.85	51.22	55.41	59.39
250.00	36.13	40.52	44.82	48.99	53.05	56.96
300.00	35.18	39.22	43.21	47.12	50.96	54.70

Source: DTN: MO0010MWDANS03.005

Table XXI-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	28.77	31.94	34.60	36.82	38.67	40.23
5.00	29.88	34.42	38.60	42.41	45.87	48.99
10.00	29.58	34.05	38.38	42.55	46.54	50.33
15.00	29.24	33.41	37.51	41.53	45.46	49.28
20.00	28.93	32.81	36.65	40.43	44.15	47.81
26.00	28.61	32.19	35.74	39.26	42.75	46.19
30.00	28.34	31.66	34.96	38.24	41.49	44.72
40.00	28.03	31.05	34.08	37.09	40.10	43.09
50.00	27.64	30.30	32.98	35.67	38.37	41.08
60.00	29.28	33.17	36.75	40.09	43.23	46.23
70.00	30.36	35.30	39.85	44.05	47.95	51.57
80.00	30.06	34.93	39.58	44.01	48.20	52.17
90.00	29.68	34.24	38.67	42.96	47.10	51.09
100.00	29.33	33.59	37.75	41.82	45.78	49.63
125.00	30.51	35.56	40.24	44.61	48.74	52.66
150.00	31.01	36.57	41.72	46.45	50.91	55.08
200.00	30.38	35.59	40.58	45.28	49.81	54.09
250.00	29.75	34.43	39.02	43.48	47.81	51.99
300.00	29.29	33.55	37.76	41.89	45.95	49.92

Source: DTN: MO0010MWDANS03.005

Table XXI-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	67.93	67.95	67.95	67.95	67.95	67.95
1.00	60.29	63.08	65.36	67.27	68.86	70.18
5.00	57.95	61.87	65.50	68.84	71.90	74.66
10.00	55.21	59.03	62.75	66.36	69.82	73.14
15.00	52.96	56.58	60.13	63.63	67.05	70.40
20.00	50.85	54.26	57.63	60.96	64.24	67.47
26.00	48.54	51.72	54.88	58.01	61.12	64.19
30.00	47.17	50.15	53.12	56.06	58.99	61.89
40.00	44.28	47.03	49.77	52.51	55.24	57.96
50.00	41.90	44.34	46.79	49.26	51.73	54.22
60.00	48.99	52.48	55.69	58.68	61.50	64.17
70.00	47.50	51.87	55.91	59.66	63.14	66.40
80.00	45.65	49.94	54.07	58.00	61.74	65.29
90.00	44.02	48.10	52.06	55.90	59.61	63.19
100.00	42.62	46.47	50.24	53.92	57.51	60.99
125.00	46.17	50.64	54.78	58.66	62.31	65.77
150.00	44.10	49.04	53.63	57.60	61.85	65.58
200.00	41.48	46.17	50.69	54.97	59.07	62.98
250.00	39.73	44.02	48.22	52.31	56.28	60.12
300.00	38.45	42.40	46.30	50.14	53.90	57.58

Source: DTN: MO0010MWDANS03.005

Table XXI-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

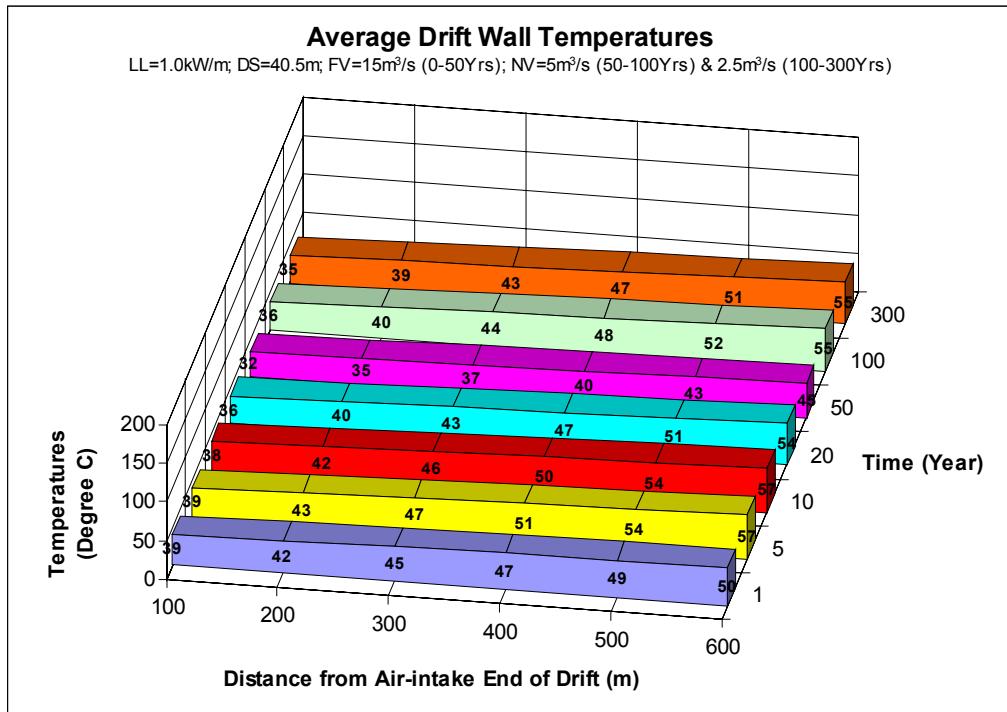
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.76	35.79	35.79	35.79	35.79	35.79
1.00	52.14	43.90	36.72	30.72	25.70	21.48
5.00	67.48	62.84	57.77	52.75	47.85	43.17
10.00	63.38	61.84	59.92	57.67	55.14	52.41
15.00	58.64	57.74	56.73	55.59	54.32	52.91
20.00	54.35	53.73	53.04	52.31	51.51	50.64
26.00	49.92	49.57	49.15	48.70	48.19	47.64
30.00	46.20	45.96	45.67	45.35	45.01	44.64
40.00	41.89	41.88	41.80	41.71	41.56	41.37
50.00	36.54	36.83	37.04	37.23	37.34	37.42
60.00	18.97	17.24	15.88	14.81	13.96	13.29
70.00	23.76	21.89	20.18	18.64	17.27	16.07
80.00	22.42	21.59	20.64	19.63	18.61	17.60
90.00	20.74	20.23	19.65	19.03	18.36	17.66
100.00	19.22	18.86	18.47	18.03	17.57	17.08
125.00	11.88	10.88	10.09	9.44	8.90	8.44
150.00	12.96	11.99	11.10	10.18	9.62	8.99
200.00	11.60	11.22	10.77	10.12	9.76	9.24
250.00	10.23	10.10	9.90	9.62	9.33	9.01
300.00	9.26	9.18	9.07	8.92	8.75	8.55

Source: DTN: MO0010MWDANS03.005

Table XXI-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.0 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 40.5 m)

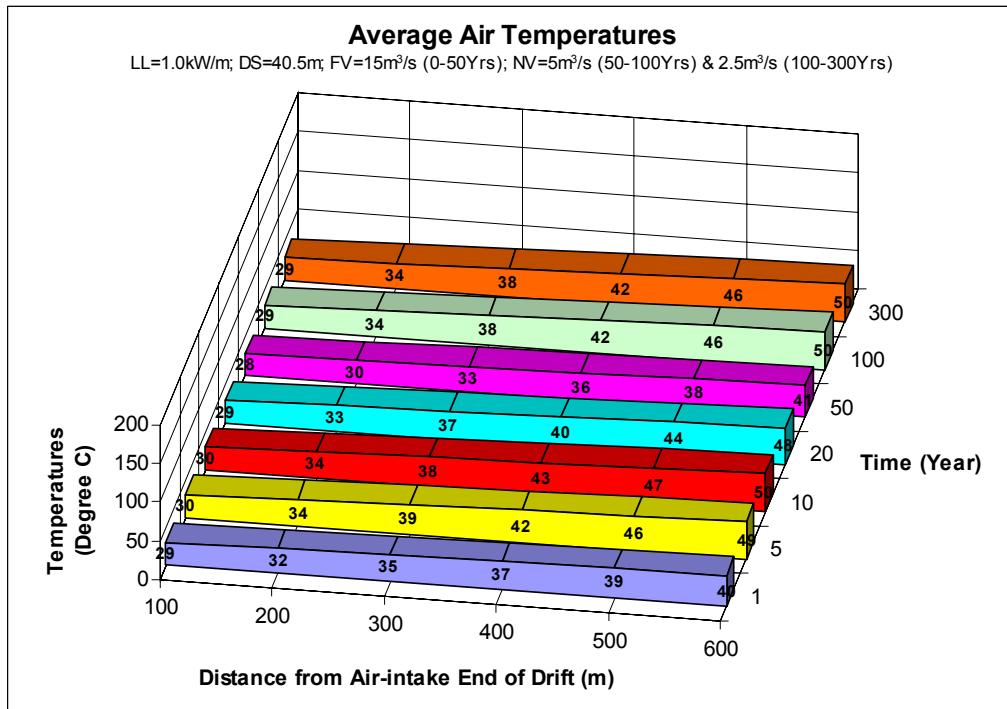
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	600.00	600.00	1.89	1.0E-4	214.72	107.36	0.34			
1.00	96.99%	581.96	590.98	18635.31	1.00	210.67	212.69	6706.86			
5.00	87.93%	527.56	554.76	69979.72	5.00	331.85	271.26	34217.85			
10.00	79.35%	476.12	501.84	79129.84	10.00	350.37	341.11	53786.26			
15.00	72.23%	433.40	454.76	71706.06	15.00	335.94	343.15	54108.31			
20.00	66.23%	397.39	415.39	65499.41	20.00	315.58	325.76	51365.92			
26.00	59.89%	359.32	378.36	71591.05	26.00	293.18	304.38	57593.51			
30.00	56.11%	336.67	348.00	43897.73	30.00	272.83	283.00	35699.05			
40.00	48.24%	289.44	313.06	98725.25	40.00	250.21	261.52	82472.76			
50.00	41.94%	251.65	270.54	85318.40	50.00	222.42	236.31	74524.24			
60.00	36.88%	221.25	236.45	74566.81	60.00	94.14	158.28	49915.53			
70.00	32.81%	196.84	209.05	65924.69	70.00	117.83	105.99	33423.80			
80.00	29.47%	176.83	186.83	58920.10	80.00	120.48	119.15	37576.41			
90.00	26.76%	160.58	168.70	53202.00	90.00	115.67	118.07	37235.95			
100.00	24.52%	147.12	153.85	48516.98	100.00	109.23	112.45	35461.67			
125.00	21.21%	127.24	137.18	108151.61	125.00	59.63	84.43	66562.55			
150.00	17.89%	107.37	117.30	92481.71	150.00	64.85	62.24	49067.24			
200.00	14.85%	89.09	98.23	154888.99	200.00	62.72	63.78	100572.61			
250.00	13.03%	78.16	83.63	131862.91	250.00	58.19	60.45	95324.48			
300.00	11.76%	70.58	74.37	117266.25	300.00	53.72	55.96	88231.44			
Total heat generated in 50 years (GJ)				604484.67	Total heat removed in 50 years (GJ)			450475.10			
Total heat generated in 100 years (GJ)				905615.27	Total heat removed in 100 years (GJ)			644088.46			
Total heat generated in 300 years (GJ)				1510266.74	Total heat removed in 300 years (GJ)			1043846.77			
Percentage of total heat removal in 50 years = 75%											
Percentage of total heat removal in 100 years = 71%											
Percentage of total heat removal in 300 years = 69%											

Source: DTN: MO0010MWDANS03.005



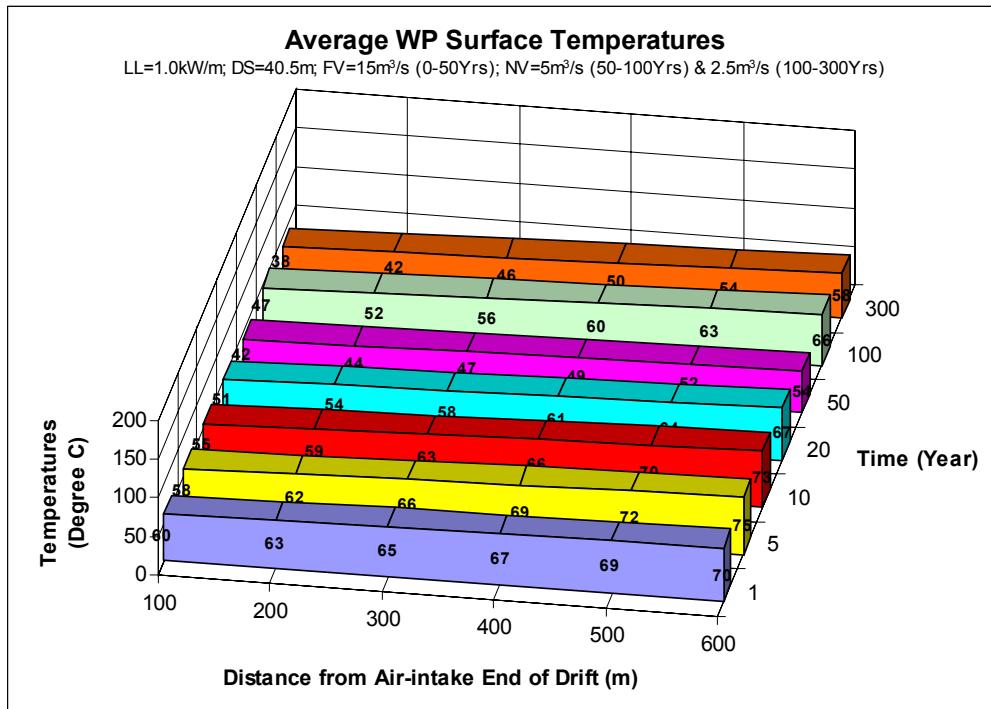
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXI-1, p. XXI-2.

Figure XXI-1. Average Drift Wall Temperatures for Case 20: LF5N5V4



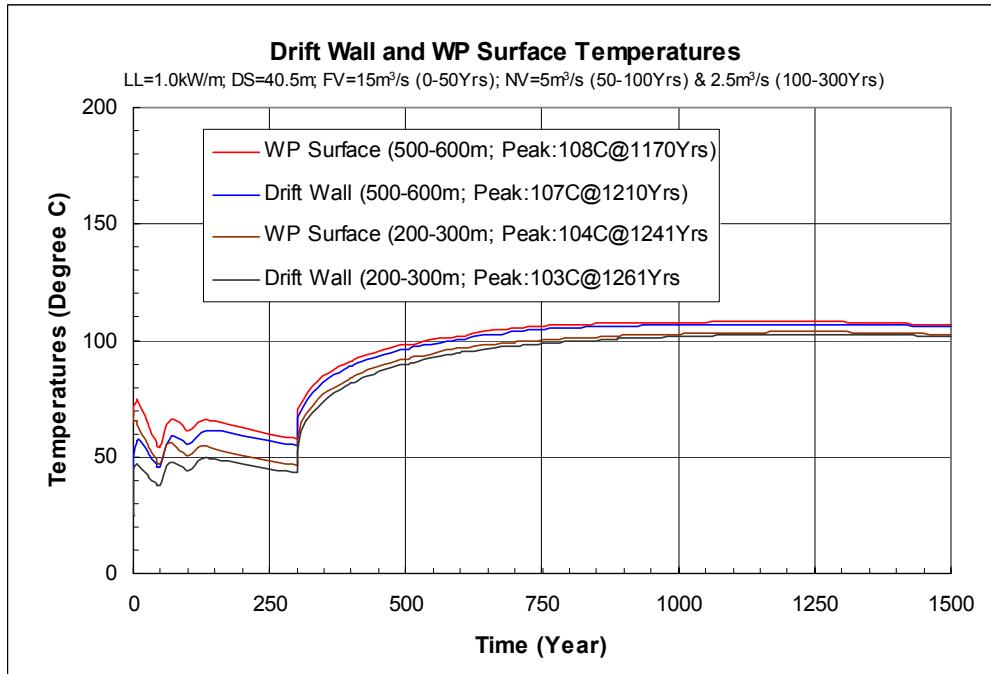
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXI-2, p. XXI-3.

Figure XXI-2. Average Air Temperatures for Case 20: LF5N5V4



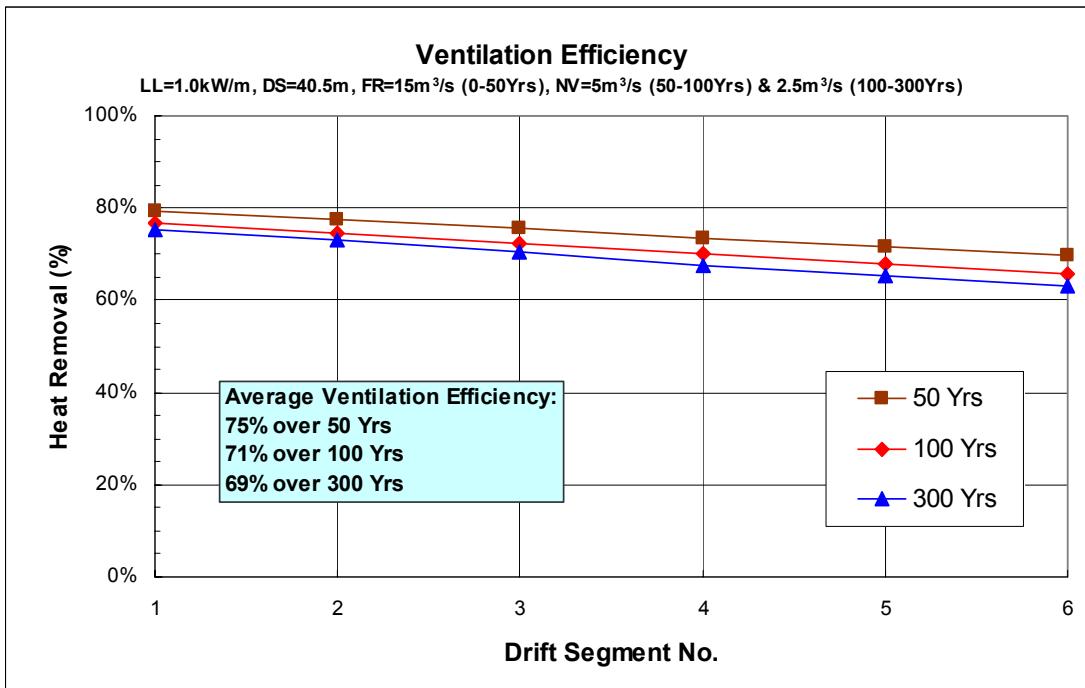
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXI-3, p. XXI-4.

Figure XXI-3. Average Waste Package Surface Temperatures for Case 20: LF5N5V4



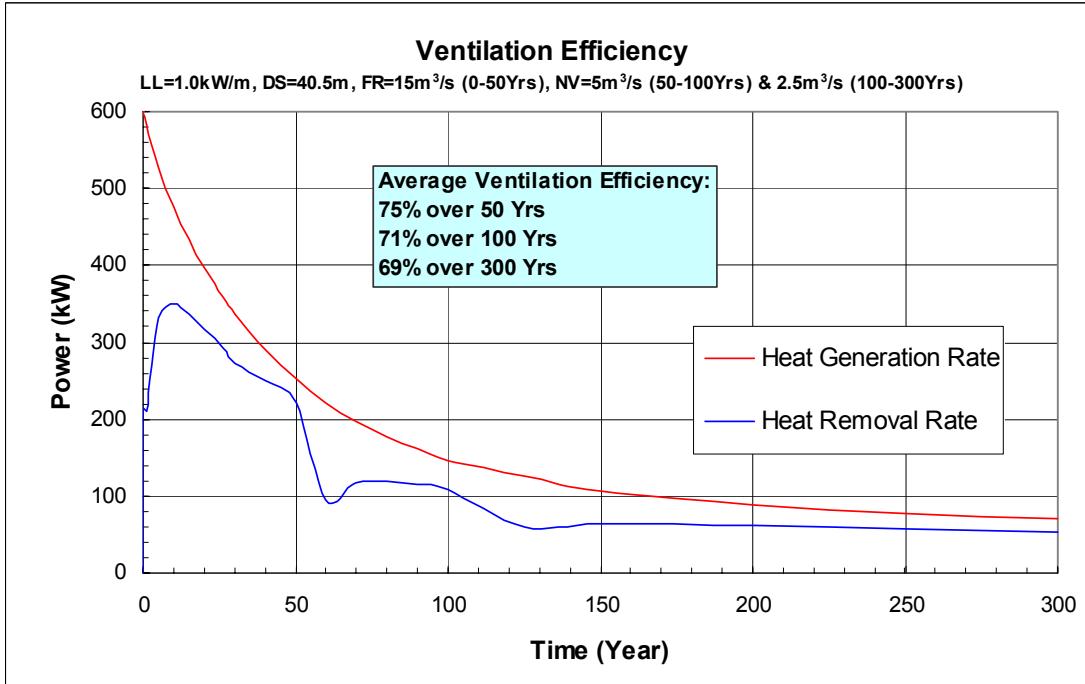
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXI-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 20: LF5N5V4



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXI-5. Average Heat Removal Rates at Different Drift Segments for Case 20: LF5N5V4



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXI-6. Overall Heat Generation and Removal Rates at Different Time for Case 20: LF5N5V4

ATTACHMENT XXII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 21: HF5N5V2

ATTACHMENT XXII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 21: HF5N5V2

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Drift spacing for this case is 25 m. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XXII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 25 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	46.16	50.14	53.33	56.00	58.24	60.10
5.00	46.05	52.46	58.33	63.67	68.50	72.85
10.00	44.65	51.08	57.32	63.33	69.08	74.56
15.00	43.14	49.22	55.21	61.09	66.87	72.50
20.00	41.80	47.48	53.12	58.71	64.23	69.69
26.00	40.31	45.58	50.83	56.06	61.26	66.44
30.00	39.39	44.30	49.22	54.12	59.00	63.87
40.00	37.42	41.88	46.36	50.85	55.35	59.85
50.00	35.81	39.72	43.68	47.67	51.70	55.76
60.00	46.78	52.46	57.71	62.65	67.32	71.80
70.00	46.53	53.68	60.33	66.54	72.33	77.78
80.00	44.90	51.99	58.83	65.41	71.70	77.71
90.00	43.38	50.07	56.63	63.05	69.32	75.42
100.00	42.03	48.30	54.51	60.63	66.65	72.57
125.00	48.66	56.03	62.95	69.50	75.74	81.73
150.00	46.92	55.09	62.78	70.02	76.85	83.33
200.00	43.80	51.47	58.97	66.25	73.28	80.05
250.00	41.72	48.58	55.43	62.23	68.94	75.51
300.00	40.21	46.44	52.70	58.95	65.19	71.37

Source: DTN: MO0010MWDANS03.005

Table XXII-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 25 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.89	34.00	37.44	40.32	42.72	44.74
5.00	32.13	38.71	44.72	50.18	55.10	59.53
10.00	31.79	38.43	44.87	51.07	57.00	62.63
15.00	31.29	37.52	43.67	49.74	55.68	61.49
20.00	30.81	36.60	42.36	48.07	53.74	59.34
26.00	30.35	35.69	41.03	46.35	51.66	56.93
30.00	29.95	34.91	39.87	44.83	49.78	54.72
40.00	29.48	33.99	38.52	43.07	47.63	52.20
50.00	28.89	32.84	36.84	40.88	44.96	49.07
60.00	31.34	37.14	42.52	47.57	52.37	56.97
70.00	33.03	40.49	47.43	53.88	59.91	65.57
80.00	32.63	40.05	47.22	54.10	60.68	66.96
90.00	32.04	38.99	45.83	52.54	59.08	65.43
100.00	31.51	37.98	44.39	50.73	56.99	63.14
125.00	33.33	41.07	48.34	55.23	61.81	68.13
150.00	34.16	42.77	50.86	58.48	65.67	72.48
200.00	33.16	41.20	49.05	56.65	63.99	71.04
250.00	32.11	39.26	46.40	53.48	60.46	67.32
300.00	31.39	37.83	44.29	50.76	57.21	63.63

Source: DTN: MO0010MWDANS03.005

Table XXII-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 25 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.04	68.04	68.04	68.04	68.04
1.00	74.52	78.00	80.83	83.20	85.19	86.85
5.00	71.66	77.24	82.40	87.11	91.37	95.23
10.00	68.05	73.65	79.12	84.43	89.55	94.45
15.00	64.73	70.05	75.33	80.56	85.72	90.77
20.00	61.87	66.88	71.88	76.87	81.82	86.74
26.00	58.73	63.42	68.11	72.81	77.50	82.19
30.00	56.81	61.20	65.60	70.02	74.44	78.86
40.00	52.66	56.70	60.76	64.86	68.98	73.11
50.00	49.26	52.82	56.45	60.12	63.84	67.59
60.00	59.63	64.85	69.70	74.26	78.59	82.75
70.00	57.82	64.48	70.70	76.53	81.98	87.12
80.00	55.13	61.75	68.18	74.38	80.33	86.03
90.00	52.78	59.05	65.23	71.30	77.25	83.04
100.00	50.75	56.64	62.50	68.30	74.02	79.67
125.00	56.36	63.36	69.95	76.20	82.18	87.92
150.00	53.41	61.24	68.63	75.60	82.20	88.46
200.00	49.29	56.67	63.90	70.95	77.76	84.34
250.00	46.62	53.23	59.86	66.45	72.96	79.37
300.00	44.69	50.72	56.78	62.85	68.91	74.94

Source: DTN: MO0010MWDANS03.005

Table XXII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 25 m)

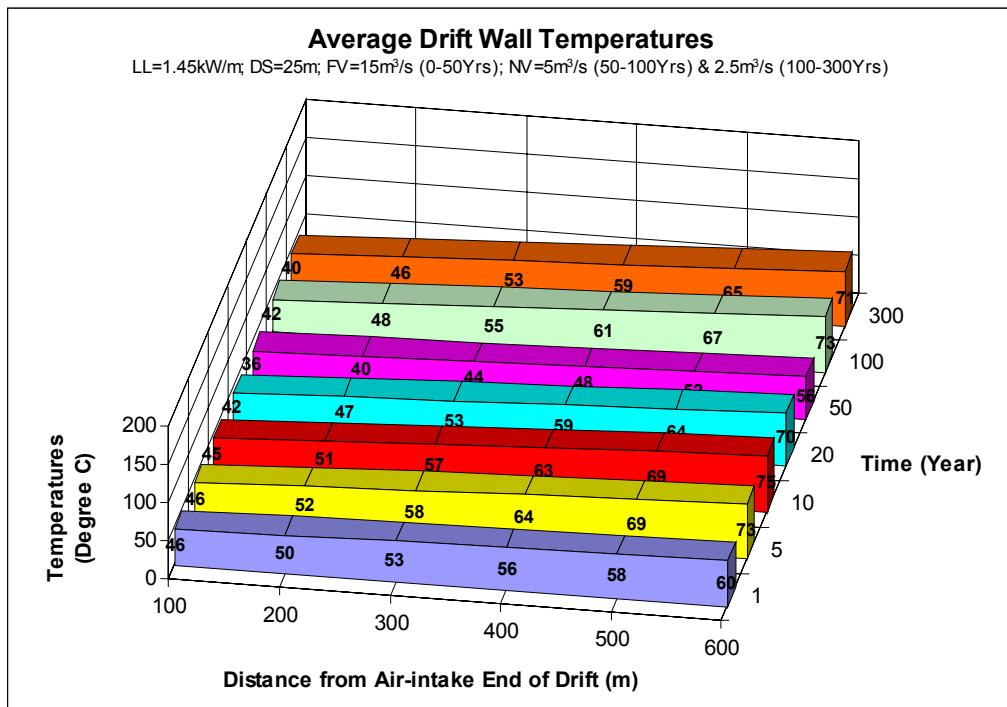
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.83	35.83	35.83	35.83	35.83
1.00	67.63	56.89	47.58	39.80	33.29	27.84
5.00	98.63	91.04	83.15	75.47	68.15	61.23
10.00	93.88	91.87	89.14	85.81	82.01	77.88
15.00	86.96	86.20	85.18	83.87	82.29	80.39
20.00	80.43	80.09	79.64	79.06	78.35	77.48
26.00	73.99	73.95	73.83	73.64	73.35	73.00
30.00	68.53	68.60	68.61	68.59	68.51	68.39
40.00	61.99	62.36	62.67	62.92	63.11	63.23
50.00	53.87	54.62	55.30	55.91	56.44	56.90
60.00	28.12	25.72	23.85	22.40	21.27	20.40
70.00	35.61	33.09	30.74	28.63	26.73	25.07
80.00	33.81	32.91	31.79	30.53	29.18	27.83
90.00	31.20	30.84	30.34	29.72	28.99	28.18
100.00	28.85	28.68	28.44	28.12	27.74	27.28
125.00	17.97	16.68	15.66	14.85	14.19	13.64
150.00	19.75	18.56	17.45	16.42	15.50	14.69
200.00	17.58	17.34	16.92	16.40	15.81	15.20
250.00	15.33	15.41	15.39	15.27	15.06	14.77
300.00	13.79	13.87	13.93	13.95	13.91	13.83

Source: DTN: MO0010MWDANS03.005

Table XXII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 25 m)

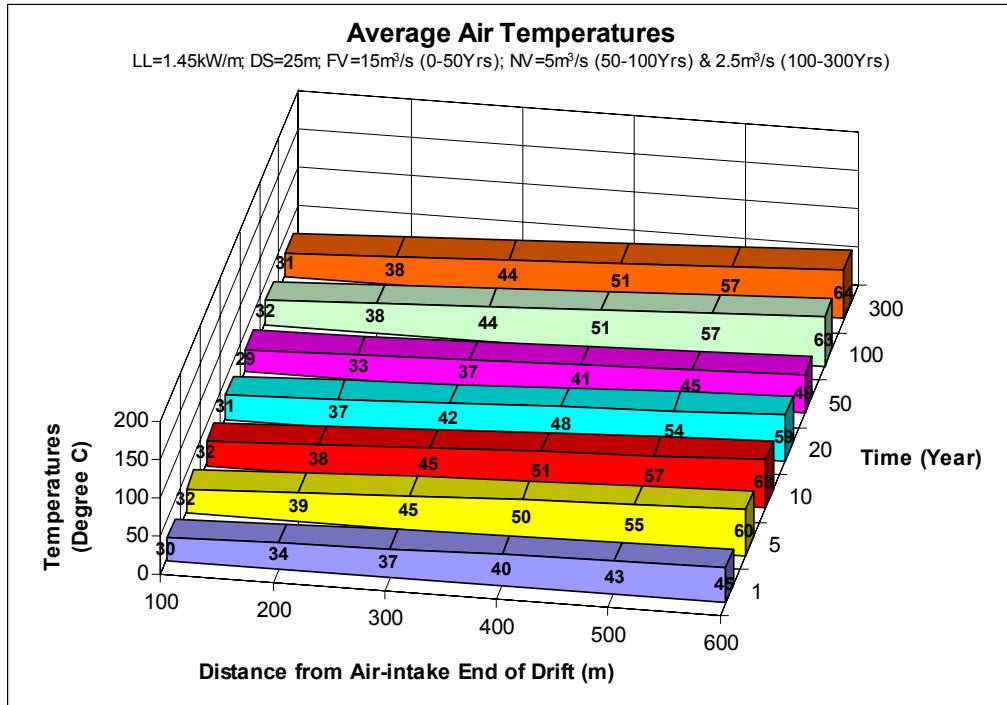
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.96	107.48	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	273.04	244.00	7693.98			
5.00	87.93%	764.96	804.40	101470.60	5.00	477.79	375.42	47356.46			
10.00	79.35%	690.37	727.67	114738.26	10.00	520.72	499.26	78722.95			
15.00	72.23%	628.43	659.40	103973.79	15.00	504.91	512.81	80860.63			
20.00	66.23%	576.22	602.32	94974.15	20.00	475.05	489.98	77259.69			
26.00	59.89%	521.01	548.62	103807.02	26.00	441.77	458.41	86738.23			
30.00	56.11%	488.18	504.60	63651.70	30.00	411.23	426.50	53800.44			
40.00	48.24%	419.68	453.93	143151.62	40.00	376.27	393.75	124174.16			
50.00	41.94%	364.89	392.29	123711.69	50.00	333.03	354.65	111843.60			
60.00	36.88%	320.81	342.85	108121.88	60.00	141.75	237.39	74864.05			
70.00	32.81%	285.42	303.12	95590.81	70.00	179.87	160.81	50712.85			
80.00	29.47%	256.40	270.91	85434.15	80.00	186.06	182.96	57699.04			
90.00	26.76%	232.84	244.62	77142.91	90.00	179.27	182.66	57604.61			
100.00	24.52%	213.32	223.08	70349.62	100.00	169.11	174.19	54933.06			
125.00	21.21%	184.50	198.91	156819.84	125.00	92.99	131.05	103322.17			
150.00	17.89%	155.68	170.09	134098.48	150.00	102.38	97.68	77013.81			
200.00	14.85%	129.19	142.43	224589.03	200.00	99.26	100.82	158965.99			
250.00	13.03%	113.33	121.26	191201.22	250.00	91.23	95.24	150180.51			
300.00	11.76%	102.34	107.84	170036.07	300.00	83.28	87.25	137582.34			
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)			668450.46			
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)			964264.07			
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)			1591328.89			
Percentage of total heat removal in 50 years = 76%											
Percentage of total heat removal in 100 years = 73%											
Percentage of total heat removal in 300 years = 73%											

Source: DTN: MO0010MWDANS03.005



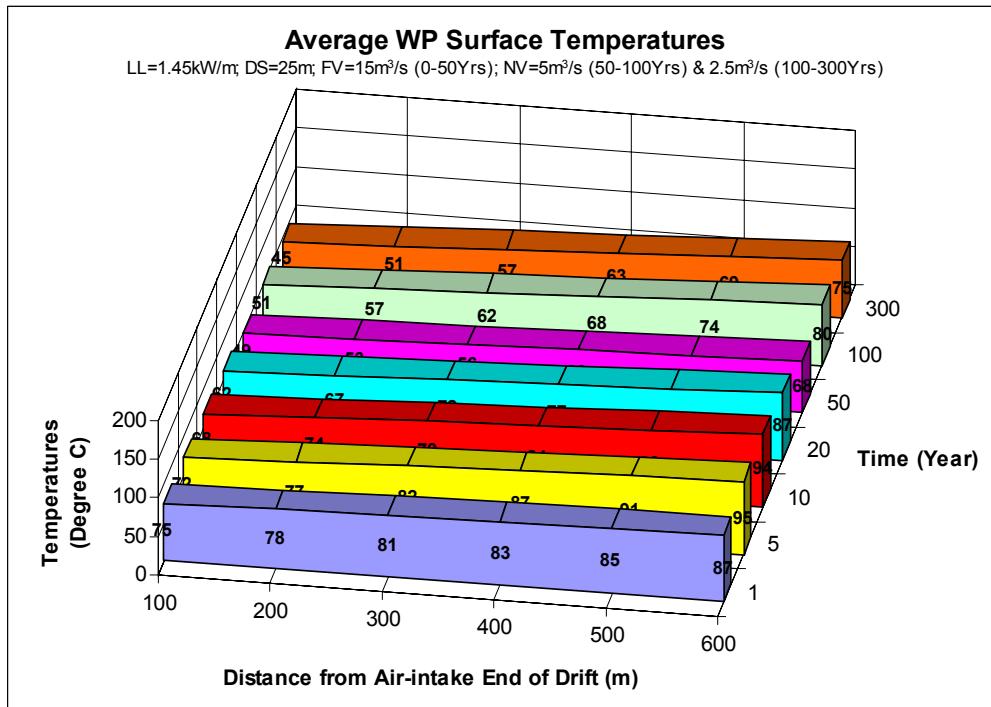
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXII-1, p. XXII-2.

Figure XXII-1. Average Drift Wall Temperatures for Case 21: HF5N5V2



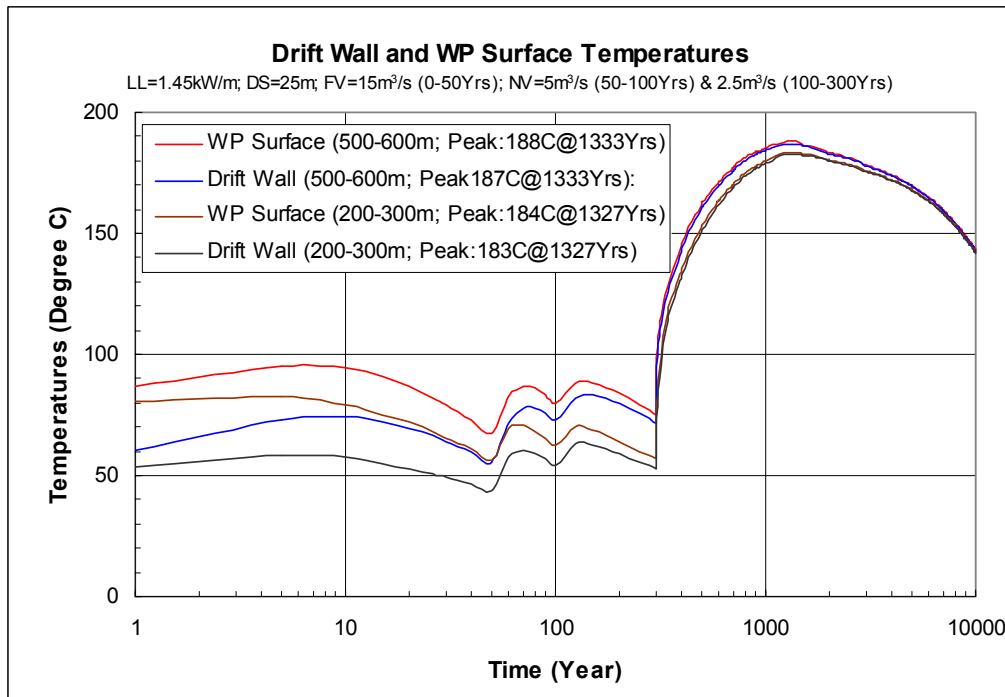
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXII-2, p. XXII-3.

Figure XXII-2. Average Air Temperatures for Case 21: HF5N5V2



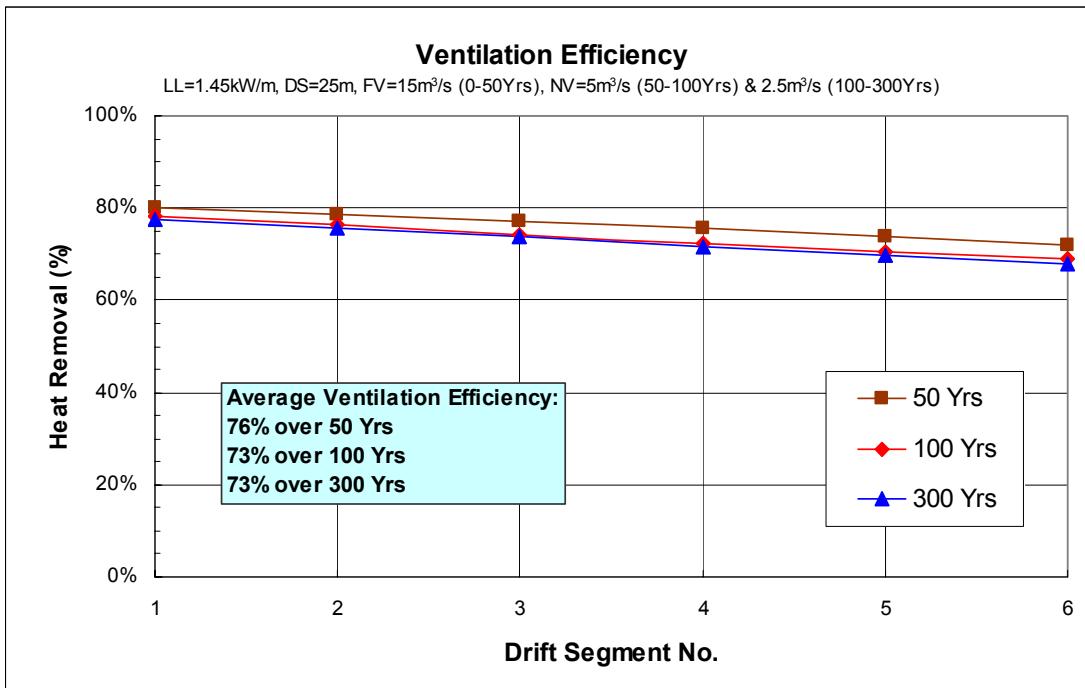
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXII-3, p. XXII-4.

Figure XXII-3. Average Waste Package Surface Temperatures for Case 21: HF5N5V2



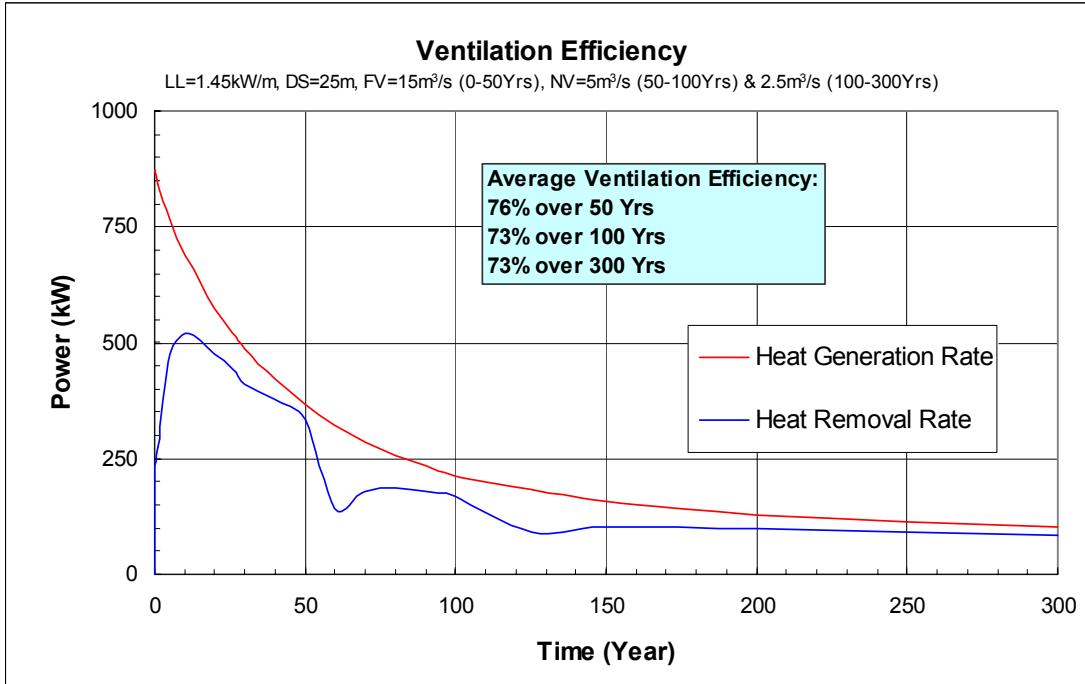
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 21: HF5N5V2



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXII-5. Average Heat Removal Rates at Different Drift Segments for Case 21: HF5N5V2



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXII-6. Overall Heat Generation and Removal Rates at Different Time for Case 21: HF5N5V2

ATTACHMENT XXIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 22: HF5N5V8KD

ATTACHMENT XXIII

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 22: HF5N5V8KD

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Thermal conductivity (*k*) values for stratigraphic units are reduced by 25 percent. Drift spacing for this case is 81 m. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XXIII-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Reduced by 25%)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	46.89	51.11	54.53	57.40	59.82	61.85
5.00	45.97	52.53	58.59	64.12	69.16	73.71
10.00	44.18	50.47	56.64	62.60	68.33	73.82
15.00	42.54	48.36	54.09	59.73	65.28	70.71
20.00	41.15	46.52	51.84	57.08	62.26	67.37
26.00	39.65	44.59	49.49	54.34	59.13	63.88
30.00	38.74	43.33	47.87	52.37	56.83	61.25
40.00	36.82	40.97	45.10	49.21	53.28	57.34
50.00	35.29	38.91	42.54	46.17	49.80	53.43
60.00	46.23	51.51	56.31	60.73	64.86	68.75
70.00	45.17	51.74	57.78	63.34	68.47	73.20
80.00	43.40	49.67	55.67	61.37	66.79	71.89
90.00	41.91	47.73	53.36	58.78	64.00	69.02
100.00	40.65	46.07	51.33	56.43	61.36	66.14
125.00	46.76	53.01	58.70	63.96	68.84	73.41
150.00	44.51	51.31	57.54	63.25	68.51	73.36
200.00	41.82	48.06	53.99	59.60	64.87	69.81
250.00	40.12	45.77	51.21	56.43	61.42	66.18
300.00	38.90	44.12	49.16	54.04	58.72	63.23

Source: DTN: MO0010MWDANS03.005

Table XXIII-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Reduced by 25%)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.98	34.19	37.72	40.70	43.20	45.30
5.00	32.21	38.90	45.04	50.64	55.72	60.31
10.00	31.72	38.32	44.74	50.95	56.90	62.57
15.00	31.16	37.25	43.25	49.17	54.98	60.66
20.00	30.66	36.27	41.82	47.31	52.73	58.08
26.00	30.19	35.34	40.45	45.51	50.52	55.48
30.00	29.80	34.56	39.28	43.96	48.61	53.21
40.00	29.33	33.65	37.95	42.22	46.48	50.71
50.00	28.76	32.53	36.31	40.10	43.89	47.68
60.00	31.18	36.76	41.86	46.59	51.02	55.21
70.00	32.73	39.84	46.36	52.35	57.87	62.98
80.00	32.18	39.07	45.65	51.90	57.80	63.36
90.00	31.57	37.94	44.10	50.04	55.76	61.24
100.00	31.06	36.95	42.67	48.22	53.60	58.80
125.00	32.74	39.74	46.15	52.07	57.59	62.78
150.00	33.38	41.03	48.03	54.44	60.33	65.77
200.00	32.35	39.37	46.03	52.29	58.16	63.66
250.00	31.46	37.71	43.73	49.51	55.04	60.30
300.00	30.86	36.55	42.06	47.38	52.51	57.45

Source: DTN: MO0010MWDANS03.005

Table XXIII-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Reduced by 25%)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.04	68.04	68.04	68.04	68.04
1.00	75.01	78.66	81.66	84.19	86.32	88.11
5.00	71.66	77.35	82.64	87.51	91.93	95.96
10.00	67.80	73.28	78.68	83.94	89.04	93.94
15.00	64.37	69.49	74.56	79.57	84.53	89.40
20.00	61.48	66.24	70.98	75.67	80.33	84.93
26.00	58.33	62.75	67.15	71.53	75.87	80.18
30.00	56.41	60.54	64.64	68.72	72.77	76.81
40.00	52.29	56.08	59.86	63.62	67.37	71.11
50.00	48.93	52.27	55.62	58.98	62.36	65.73
60.00	59.22	64.10	68.55	72.65	76.49	80.12
70.00	56.75	62.89	68.56	73.79	78.62	83.10
80.00	53.95	59.83	65.48	70.87	76.00	80.85
90.00	51.61	57.10	62.42	67.57	72.53	77.31
100.00	49.64	54.78	59.77	64.62	69.32	73.88
125.00	54.73	60.69	66.13	71.16	75.84	80.23
150.00	51.31	57.86	63.86	69.38	74.46	79.15
200.00	47.56	53.59	59.34	64.78	69.90	74.71
250.00	45.22	50.70	55.98	61.06	65.92	70.56
300.00	43.54	48.61	53.52	58.27	62.84	67.24

Source: DTN: MO0010MWDANS03.005

Table XXIII-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Reduced by 25%)

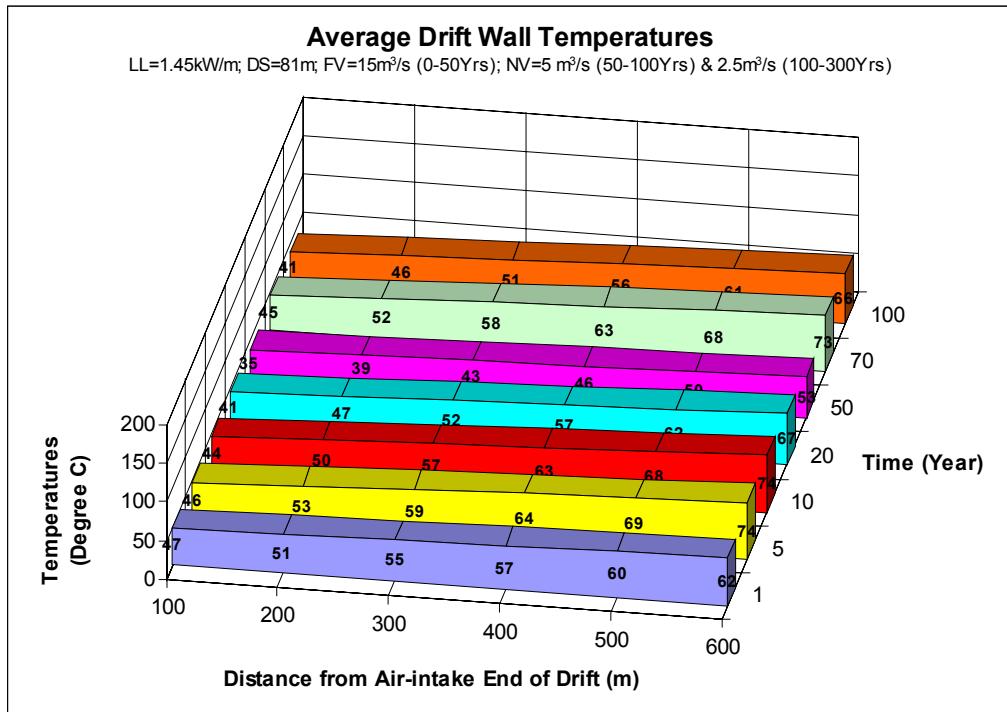
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.83	35.83	35.83	35.83	35.83
1.00	68.87	58.21	48.95	41.15	34.60	29.09
5.00	99.76	92.53	84.96	77.49	70.30	63.48
10.00	93.00	91.24	88.85	85.85	82.36	78.51
15.00	85.20	84.21	83.13	81.83	80.35	78.61
20.00	78.35	77.57	76.77	75.91	75.01	74.02
26.00	71.81	71.24	70.64	70.02	69.36	68.66
30.00	66.35	65.85	65.33	64.80	64.24	63.69
40.00	59.91	59.72	59.47	59.18	58.84	58.51
50.00	52.00	52.20	52.33	52.40	52.40	52.38
60.00	27.38	24.75	22.64	20.97	19.64	18.58
70.00	34.28	31.50	28.92	26.58	24.48	22.63
80.00	31.82	30.58	29.18	27.69	26.16	24.64
90.00	29.13	28.24	27.32	26.35	25.35	24.31
100.00	26.86	26.12	25.37	24.61	23.84	23.07
125.00	16.69	15.09	13.81	12.77	11.91	11.18
150.00	18.06	16.51	15.09	13.82	12.70	11.71
200.00	15.86	15.14	14.34	13.50	12.66	11.84
250.00	13.92	13.47	12.99	12.46	11.91	11.34
300.00	12.64	12.26	11.88	11.48	11.06	10.64

Source: DTN: MO0010MWDANS03.005

Table XXIII-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Reduced by 25%)

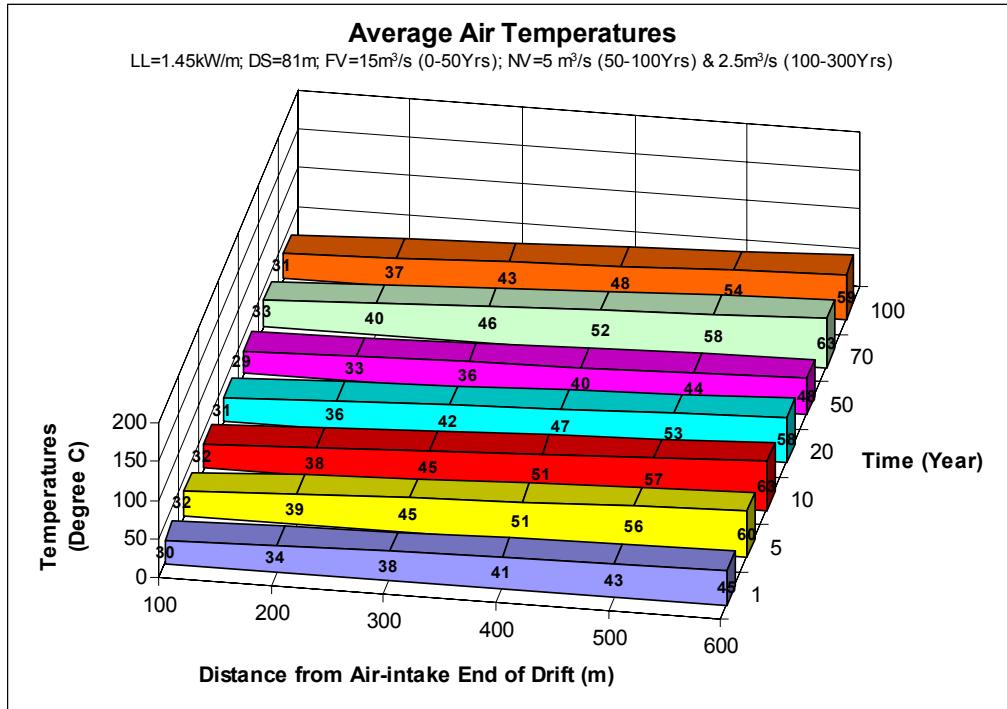
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07			
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31			
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37			
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24			
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48			
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32			
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75			
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73			
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19			
60.00	36.88%	320.81	342.85	108121.88	60.00	129.58	218.90	69033.77			
70.00	32.81%	285.42	303.12	95590.81	70.00	160.57	145.08	45751.71			
80.00	29.47%	256.40	270.91	85434.15	80.00	161.87	161.22	50843.16			
90.00	26.76%	232.84	244.62	77142.91	90.00	153.49	157.68	49725.69			
100.00	24.52%	213.32	223.08	70349.62	100.00	143.84	148.67	46883.25			
125.00	21.21%	184.50	198.91	156819.84	125.00	77.60	110.72	87292.74			
150.00	17.89%	155.68	170.09	134098.48	150.00	83.01	80.30	63310.14			
200.00	14.85%	129.19	142.43	224589.03	200.00	78.96	80.98	127693.79			
250.00	13.03%	113.33	121.26	191201.22	250.00	72.73	75.84	119591.31			
300.00	11.76%	102.34	107.84	170036.07	300.00	67.41	70.07	110488.47			
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)			630434.80			
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)			892672.39			
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)			1401048.83			
Percentage of total heat removal in 50 years = 72%											
Percentage of total heat removal in 100 years = 68%											
Percentage of total heat removal in 300 years = 64%											

Source: DTN: MO0010MWDANS03.005



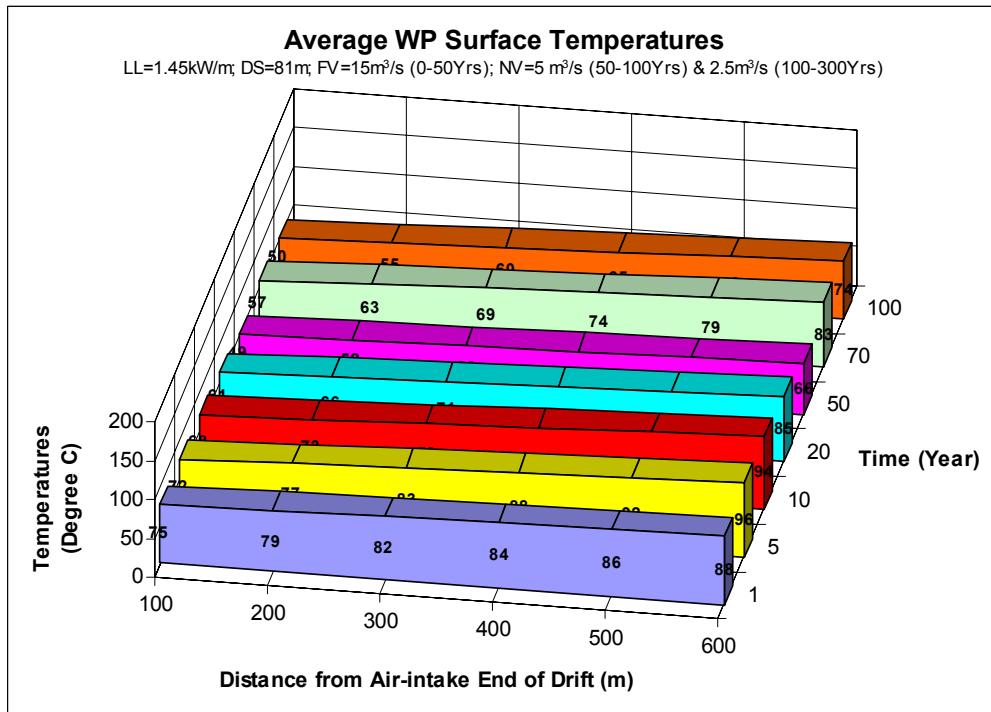
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXIII-1, p. XXIII-2.

Figure XXIII-1. Average Drift Wall Temperatures for Case 22: HF5N5V8KD



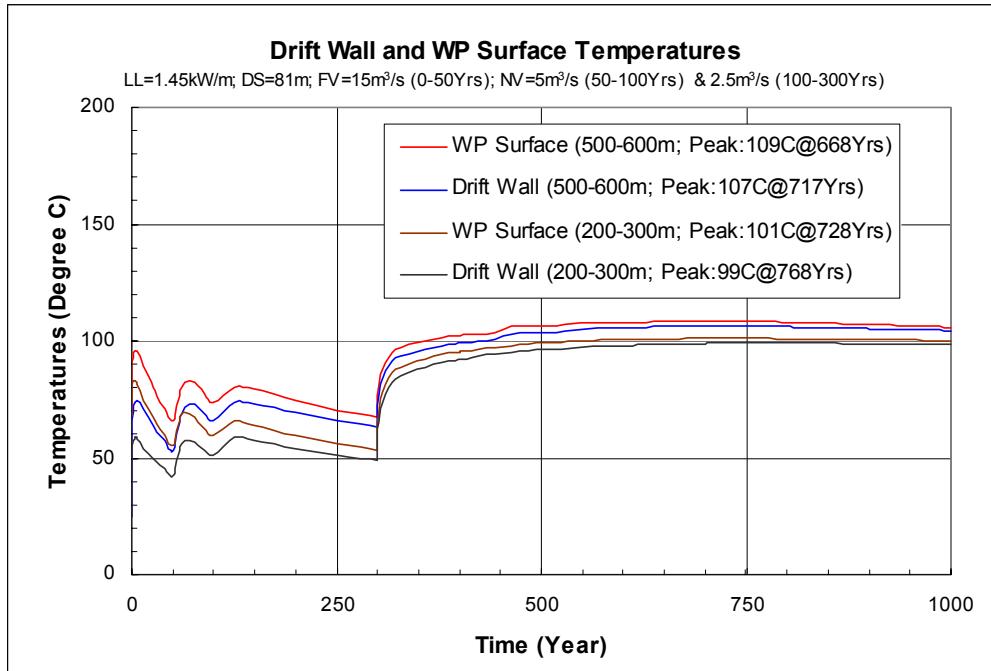
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXIII-2, p. XXIII-3.

Figure XXIII-2. Average Air Temperatures for Case 22: HF5N5V8KD



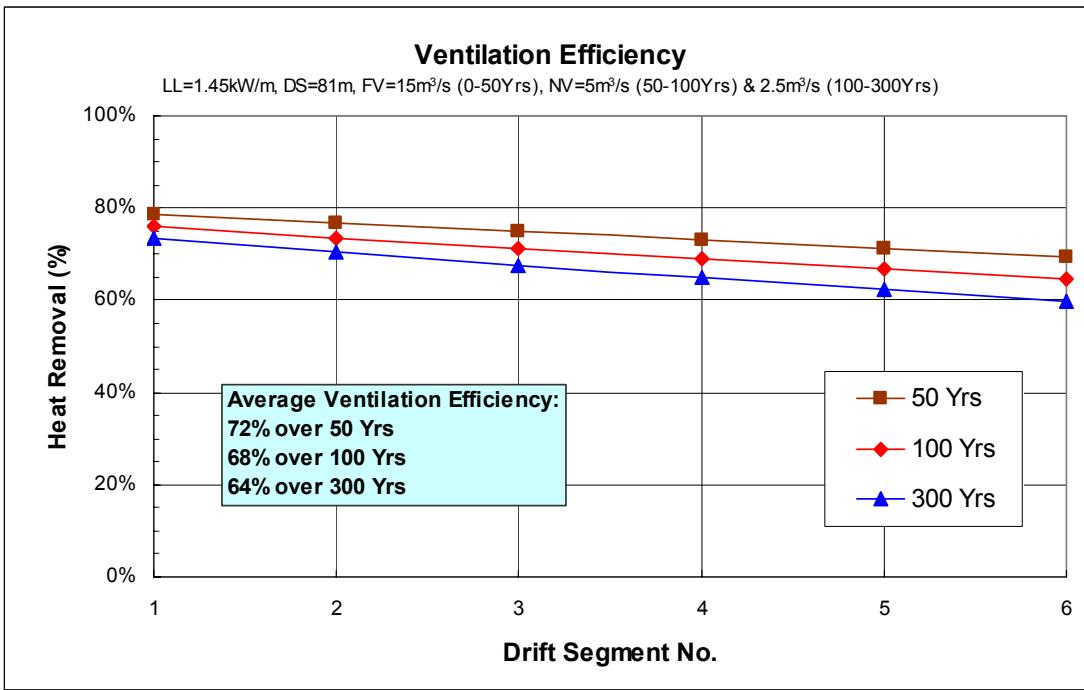
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXIII-3, p. XXIII-4.

Figure XXIII-3. Average Waste Package Surface Temperatures for Case 22: HF5N5V8KD



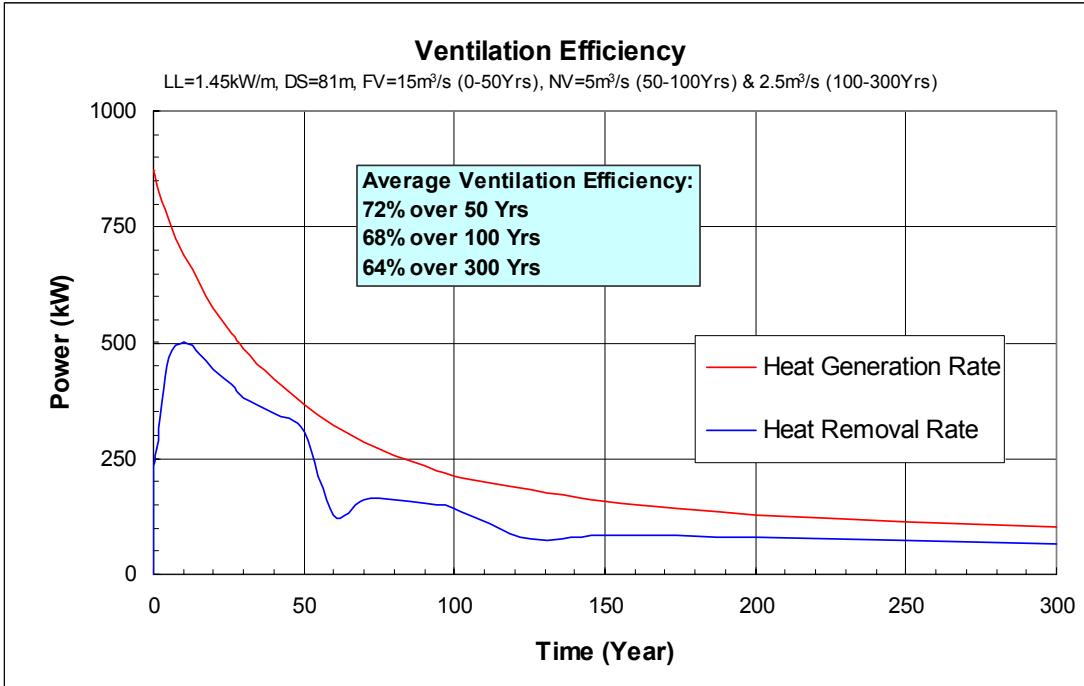
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXIII-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 22: HF5N5V8KD



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXIII-5. Average Heat Removal Rates at Different Drift Segments for Case 22: HF5N5V8KD



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXIII-6. Overall Heat Generation and Removal Rates at Different Time for Case 22: HF5N5V8KD

ATTACHMENT XXIV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 23: HF5N5V8KU

ATTACHMENT XXIV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 23: HF5N5V8KU

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Thermal conductivity values for stratigraphic units are raised by 25 percent. Drift spacing for this case is 81 m. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XXIV-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Raised by 25%)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
1.00	45.48	49.22	52.22	54.71	56.78	58.51
5.00	44.96	50.88	56.28	61.16	65.54	69.46
10.00	43.38	49.17	54.73	60.05	65.10	69.87
15.00	41.88	47.27	52.52	57.62	62.56	67.33
20.00	40.60	45.62	50.52	55.30	59.97	64.52
26.00	39.22	43.87	48.43	52.88	57.25	61.53
30.00	38.38	42.72	46.97	51.14	55.24	59.26
40.00	36.59	40.54	44.44	48.28	52.06	55.79
50.00	35.13	38.62	42.08	45.53	48.94	52.31
60.00	44.69	49.43	53.75	57.70	61.38	64.83
70.00	43.94	49.74	55.00	59.80	64.19	68.21
80.00	42.45	48.06	53.34	58.27	62.87	67.17
90.00	41.16	46.44	51.47	56.23	60.73	64.98
100.00	40.06	45.04	49.79	54.33	58.65	62.75
125.00	45.08	50.60	55.58	60.11	64.28	68.14
150.00	43.35	49.29	54.66	59.50	63.90	67.91
200.00	41.12	46.75	51.97	56.80	61.25	65.35
250.00	39.66	44.87	49.78	54.40	58.71	62.75
300.00	38.58	43.47	48.11	52.51	56.66	60.57

Source: DTN: MO0010MWDANS03.005

Table XXIV-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Raised by 25%)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.81	33.83	37.18	39.96	42.28	44.22
5.00	31.91	38.24	43.99	49.17	53.81	57.96
10.00	31.50	37.78	43.82	49.58	55.04	60.17
15.00	30.98	36.81	42.50	48.03	53.39	58.57
20.00	30.51	35.91	41.19	46.36	51.40	56.31
26.00	30.07	35.05	39.93	44.72	49.42	54.01
30.00	29.70	34.31	38.85	43.31	47.69	51.98
40.00	29.25	33.46	37.61	41.70	45.74	49.71
50.00	28.71	32.40	36.08	39.73	43.35	46.94
60.00	30.90	36.20	41.01	45.43	49.55	53.42
70.00	32.29	38.89	44.87	50.30	55.25	59.78
80.00	31.83	38.26	44.29	49.91	55.15	60.01
90.00	31.29	37.29	42.99	48.39	53.49	58.30
100.00	30.84	36.43	41.77	46.87	51.72	56.34
125.00	32.32	38.85	44.73	50.09	55.02	59.57
150.00	32.85	39.89	46.21	51.90	57.05	61.73
200.00	32.01	38.54	44.60	50.18	55.32	60.05
250.00	31.24	37.16	42.75	48.00	52.92	57.51
300.00	30.72	36.17	41.36	46.29	50.94	55.33

Source: DTN: MO0010MWDANS03.005

Table XXIV-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Raised by 25%)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.04	68.04	68.04	68.04	68.04
1.00	74.08	77.37	80.05	82.29	84.15	85.70
5.00	70.92	76.13	80.90	85.24	89.14	92.62
10.00	67.19	72.29	77.22	81.96	86.49	90.78
15.00	63.87	68.66	73.34	77.91	82.36	86.68
20.00	61.05	65.54	69.95	74.26	78.49	82.62
26.00	57.98	62.18	66.31	70.36	74.34	78.25
30.00	56.11	60.05	63.92	67.73	71.48	75.17
40.00	52.08	55.71	59.31	62.86	66.36	69.82
50.00	48.78	52.01	55.23	58.44	61.62	64.78
60.00	57.92	62.34	66.35	70.04	73.46	76.68
70.00	55.70	61.16	66.13	70.67	74.81	78.62
80.00	53.11	58.42	63.42	68.11	72.49	76.58
90.00	50.95	55.96	60.74	65.28	69.58	73.64
100.00	49.10	53.85	58.39	62.72	66.86	70.80
125.00	53.22	58.50	63.28	67.63	71.64	75.34
150.00	50.25	56.00	61.19	65.88	70.15	74.04
200.00	46.90	52.37	57.44	62.15	66.49	70.49
250.00	44.78	49.85	54.63	59.14	63.35	67.30
300.00	43.23	48.00	52.52	56.82	60.88	64.71

Source: DTN: MO0010MWDANS03.005

Table XXIV-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Raised by 25%)

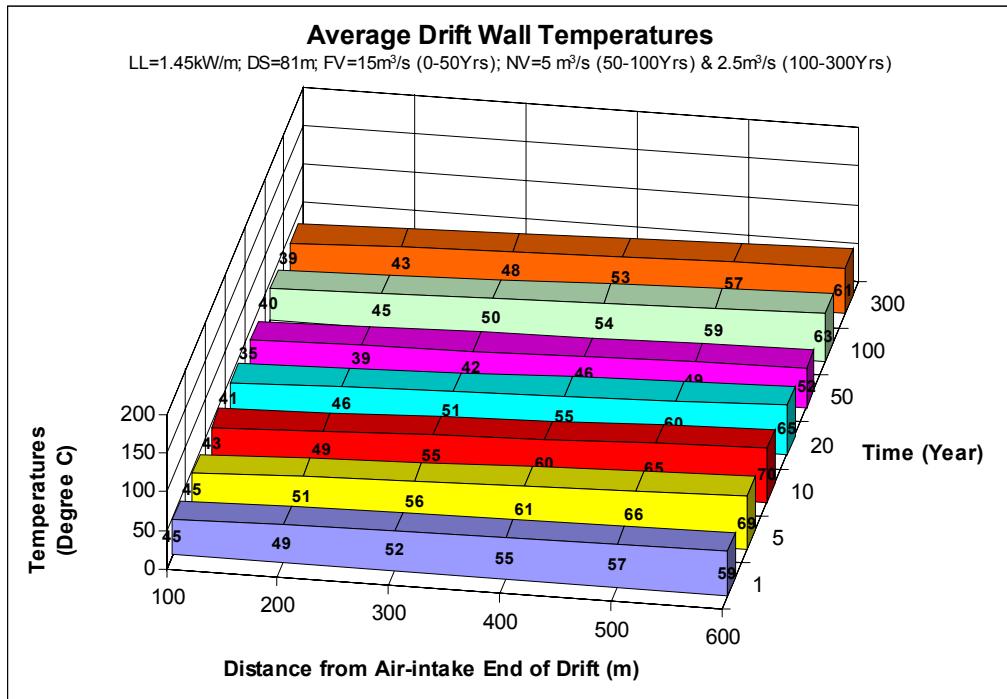
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.83	35.83	35.83	35.83	35.83
1.00	66.49	55.65	46.32	38.57	32.10	26.72
5.00	95.64	87.60	79.44	71.64	64.25	57.37
10.00	89.89	86.98	83.53	79.67	75.47	71.06
15.00	82.67	80.75	78.69	76.51	74.16	71.64
20.00	76.26	74.68	73.07	71.44	69.76	68.02
26.00	70.12	68.86	67.59	66.27	64.95	63.60
30.00	64.97	63.89	62.78	61.67	60.55	59.43
40.00	58.85	58.17	57.43	56.65	55.83	54.99
50.00	51.30	51.11	50.85	50.52	50.11	49.65
60.00	26.18	23.47	21.32	19.62	18.25	17.15
70.00	32.32	29.26	26.52	24.08	21.95	20.10
80.00	30.27	28.52	26.73	24.95	23.21	21.57
90.00	27.91	26.58	25.26	23.94	22.63	21.35
100.00	25.90	24.78	23.68	22.60	21.53	20.48
125.00	15.79	14.07	12.68	11.56	10.62	9.83
150.00	16.93	15.17	13.63	12.27	11.10	10.09
200.00	15.11	14.09	13.05	12.04	11.08	10.18
250.00	13.46	12.76	12.05	11.33	10.60	9.90
300.00	12.32	11.76	11.19	10.62	10.04	9.47

Source: DTN: MO0010MWDANS03.005

Table XXIV-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Thermal Conductivity Values Raised by 25%)

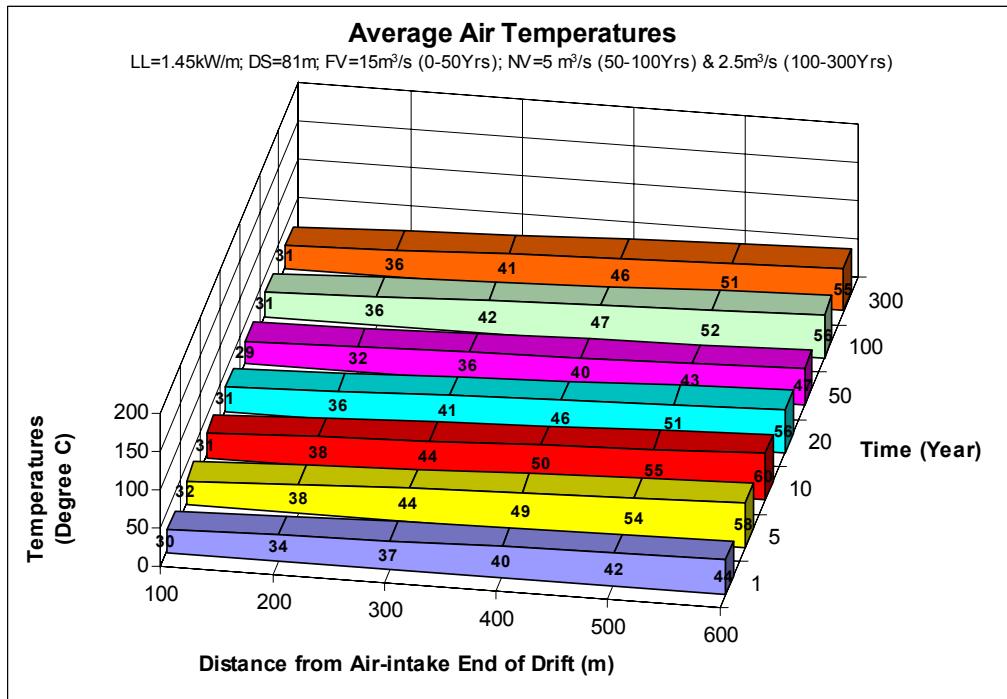
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.0E-4	100.00%	870.00	870.00	2.74	1.0E-4	214.82	107.41	0.34			
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07			
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31			
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37			
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24			
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48			
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32			
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75			
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73			
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19			
60.00	36.88%	320.81	342.85	108121.88	60.00	129.58	218.90	69033.77			
70.00	32.81%	285.42	303.12	95590.81	70.00	160.57	145.08	45751.71			
80.00	29.47%	256.40	270.91	85434.15	80.00	161.87	161.22	50843.16			
90.00	26.76%	232.84	244.62	77142.91	90.00	153.49	157.68	49725.69			
100.00	24.52%	213.32	223.08	70349.62	100.00	143.84	148.67	46883.25			
125.00	21.21%	184.50	198.91	156819.84	125.00	77.60	110.72	87292.74			
150.00	17.89%	155.68	170.09	134098.48	150.00	83.01	80.30	63310.14			
200.00	14.85%	129.19	142.43	224589.03	200.00	78.96	80.98	127693.79			
250.00	13.03%	113.33	121.26	191201.22	250.00	72.73	75.84	119591.31			
300.00	11.76%	102.34	107.84	170036.07	300.00	67.41	70.07	110488.47			
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)			630434.80			
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)			892672.39			
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)			1401048.83			
Percentage of total heat removal in 50 years = 72%											
Percentage of total heat removal in 100 years = 68%											
Percentage of total heat removal in 300 years = 64%											

Source: DTN: MO0010MWDANS03.005



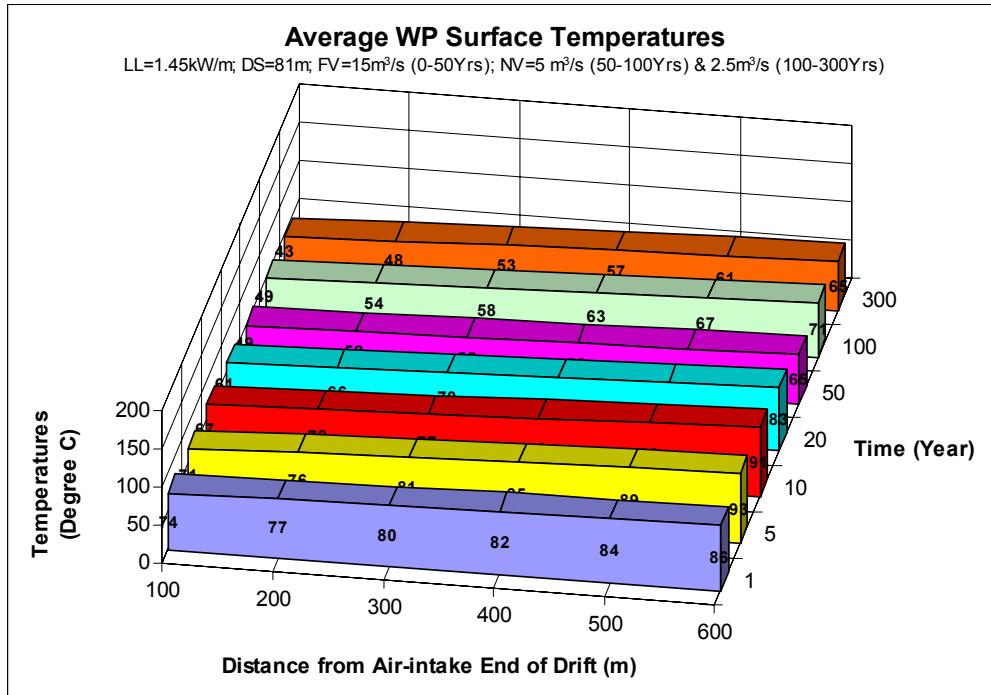
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXIV-1, p. XXIV-2.

Figure XXIV-1. Average Drift Wall Temperatures for Case 23: HF5N5V8KU



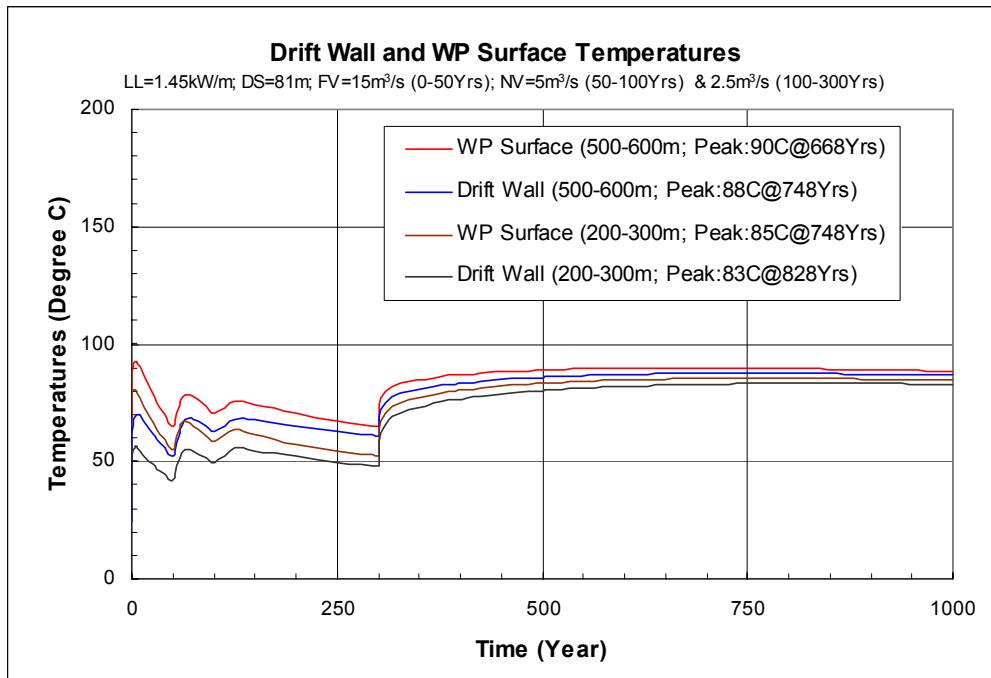
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXIV-2, p. XXIV-3.

Figure XXIV-2. Average Air Temperatures for Case 23: HF5N5V8KU



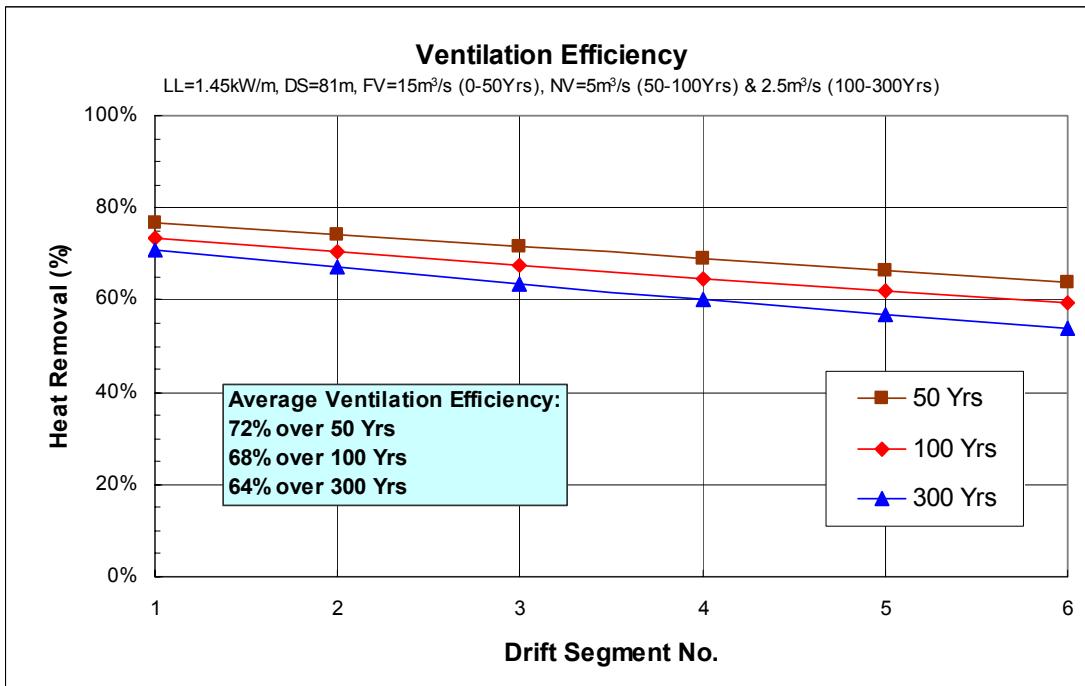
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXIV-3, p. XXIV-4.

Figure XXIV-3. Average Waste Package Surface Temperatures for Case 23: HF5N5V8KU



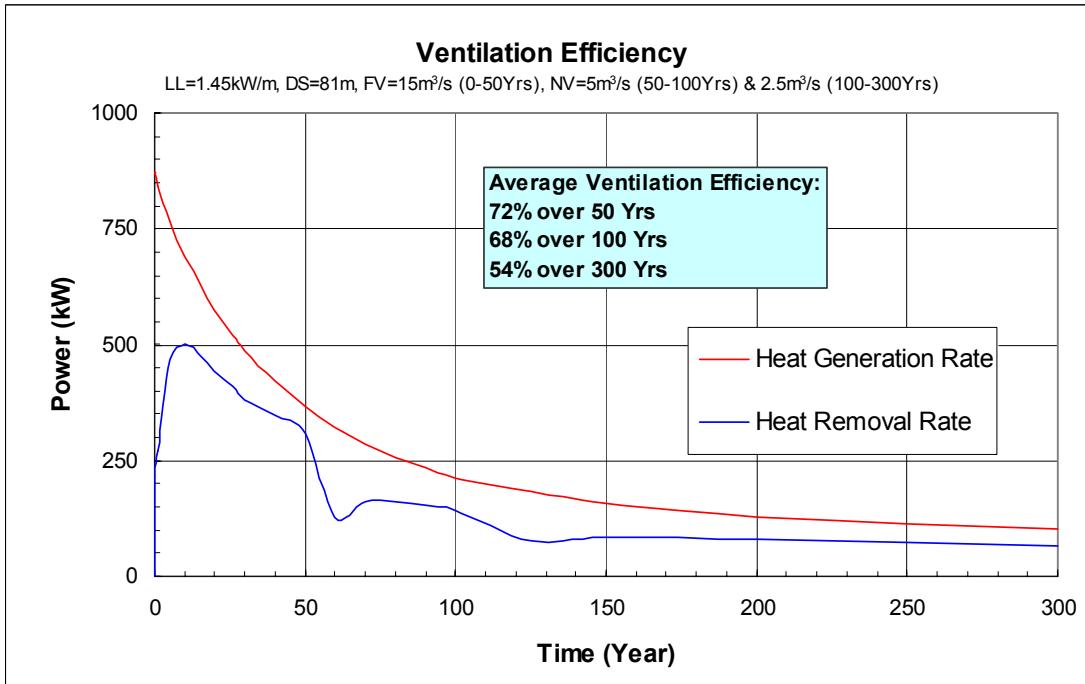
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXIV-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 23: HF5N5V8KU



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXIV-5. Average Heat Removal Rates at Different Drift Segments for Case 23: HF5N5V8KU



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXIV-6. Overall Heat Generation and Removal Rates at Different Time for Case 23: HF5N5V8KU

ATTACHMENT XXV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 24: HF5N5V8A

ATTACHMENT XXV

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 24: HF5N5V8A

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 5 m³/s from 50 to 100 years and 2.5 m³/s from 100 to 300 years. Waste is aged for additional 18 years. Drift spacing for this case is 81 m. Ventilation efficiency is calculated for up to 300 years. All data presented in this attachment are obtained from DTN: MO0010MWDANS03.005.

Table XXV-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Waste Aged for Additional 18 Years)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.23	25.23	25.23	25.23	25.23
2.00	39.68	42.91	45.51	47.71	49.56	51.12
7.00	39.04	43.42	47.50	51.24	54.67	57.78
12.00	38.13	42.37	46.47	50.44	54.24	57.87
17.00	37.23	41.22	45.12	48.93	52.64	56.25
22.00	36.40	40.14	43.81	47.41	50.94	54.39
27.00	35.65	39.16	42.62	46.00	49.34	52.61
32.00	34.97	38.27	41.52	44.72	47.87	50.95
42.00	33.83	36.86	39.85	42.82	45.74	48.63
50.00	33.24	36.02	38.76	41.49	44.19	46.87
57.00	41.69	45.71	49.34	52.66	55.73	58.60
62.00	41.96	47.03	51.63	55.79	59.59	63.07
72.00	40.88	46.00	50.80	55.27	59.44	63.30
82.00	39.82	44.69	49.32	53.71	57.87	61.79
100.00	38.81	43.43	47.85	52.08	56.12	59.96
107.00	44.49	49.71	54.42	58.71	62.65	66.31
132.00	43.30	49.20	54.48	59.24	63.53	67.43
182.00	41.06	46.70	51.94	56.78	61.23	65.32
232.00	39.58	44.80	49.73	54.36	58.71	62.77
300.00	38.20	43.05	47.68	52.08	56.26	60.20

Source: DTN: MO0010MWDANS03.005

Table XXV-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 5 m^3/s (50-100 Years), and 2.5 m^3/s (100-300 Years) (Drift Spacing = 81 m, Waste Aged for Additional 18 Years)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
2.00	28.81	32.03	34.75	37.03	38.95	40.57
7.00	29.94	34.57	38.83	42.75	46.31	49.54
12.00	29.66	34.20	38.60	42.84	46.90	50.76
17.00	29.35	33.61	37.78	41.86	45.84	49.71
22.00	29.05	33.03	36.95	40.79	44.56	48.25
27.00	28.78	32.51	36.17	39.78	43.33	46.81
32.00	28.54	32.03	35.47	38.86	42.19	45.48
42.00	28.23	31.43	34.60	37.73	40.83	43.89
50.00	27.94	30.85	33.75	36.62	39.47	42.29
57.00	29.95	34.38	38.38	42.05	45.44	48.62
62.00	31.37	37.12	42.31	47.01	51.28	55.17
72.00	31.18	36.98	42.40	47.44	52.11	56.45
82.00	30.76	36.25	41.47	46.41	51.09	55.49
100.00	30.37	35.51	40.44	45.15	49.64	53.92
107.00	31.96	38.13	43.68	48.73	53.37	57.66
132.00	32.74	39.64	45.81	51.34	56.34	60.86
182.00	31.99	38.51	44.54	50.09	55.19	59.87
232.00	31.22	37.13	42.71	47.97	52.89	57.49
300.00	30.63	36.02	41.17	46.08	50.73	55.13

Source: DTN: MO0010MWDANS03.005

Table XXV-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Waste Aged for Additional 18 Years)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	67.93	67.94	67.94	67.94	67.94	67.94
2.00	60.39	63.34	65.72	67.76	69.46	70.90
7.00	58.20	62.18	65.91	69.33	72.48	75.34
12.00	55.98	59.84	63.59	67.22	70.72	74.08
17.00	53.90	57.55	61.13	64.63	68.06	71.40
22.00	51.98	55.43	58.81	62.14	65.41	68.62
27.00	50.26	53.51	56.71	59.85	62.96	66.01
32.00	48.69	51.76	54.79	57.77	60.71	63.60
42.00	46.04	48.88	51.69	54.48	57.23	59.95
50.00	44.67	47.28	49.87	52.44	54.99	57.52
57.00	53.16	56.94	60.37	63.49	66.38	69.08
62.00	52.75	57.57	61.93	65.90	69.50	72.80
72.00	50.75	55.61	60.18	64.45	68.42	72.12
82.00	48.93	53.57	57.99	62.19	66.17	69.94
100.00	47.22	51.64	55.87	59.92	63.80	67.49
107.00	52.73	57.73	62.23	66.35	70.13	73.64
132.00	50.23	55.93	61.04	65.65	69.80	73.58
182.00	46.86	52.34	57.43	62.14	66.47	70.46
232.00	44.72	49.80	54.60	59.11	63.36	67.33
300.00	42.74	47.48	51.99	56.29	60.38	64.24

Source: DTN: MO0010MWDANS03.005

Table XXV-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Waste Aged for Additional 18 Years)

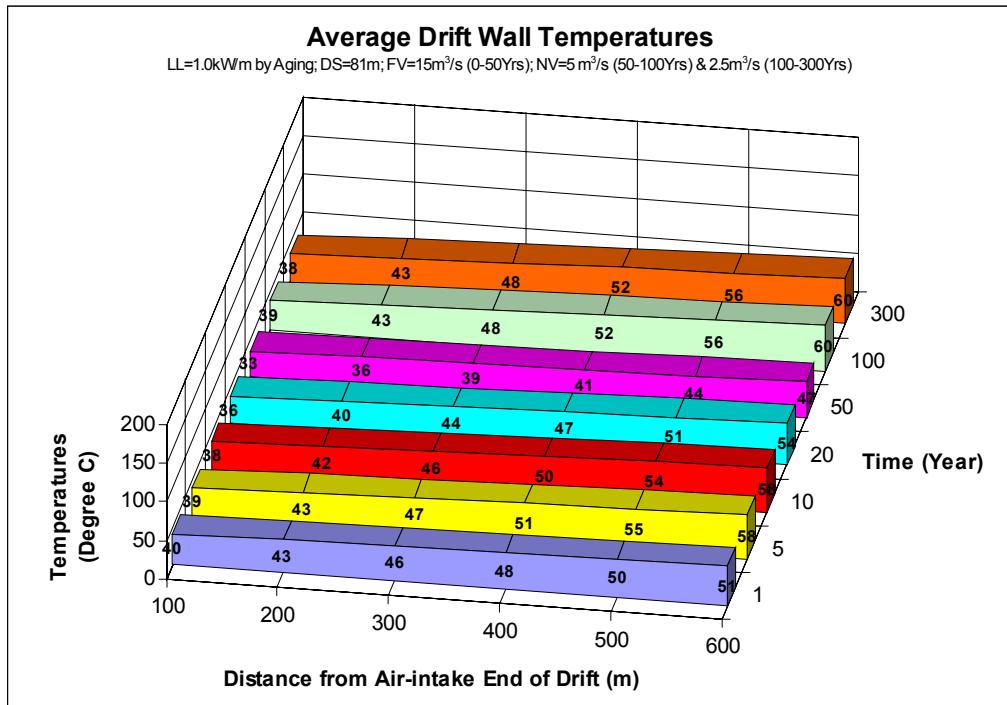
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.76	35.79	35.79	35.79	35.79	35.79
2.00	52.71	44.62	37.52	31.59	26.58	22.37
7.00	68.38	63.95	59.05	54.14	49.33	44.69
12.00	64.41	62.83	60.90	58.64	56.14	53.42
17.00	60.11	58.97	57.75	56.44	55.04	53.52
22.00	56.05	55.11	54.13	53.14	52.12	51.06
27.00	52.34	51.53	50.72	49.89	49.05	48.20
32.00	48.98	48.29	47.59	46.87	46.15	45.42
42.00	44.70	44.29	43.83	43.35	42.84	42.30
50.00	40.62	40.36	40.04	39.73	39.38	39.02
57.00	21.96	19.62	17.75	16.26	15.06	14.09
62.00	28.24	25.49	23.02	20.84	18.93	17.26
72.00	27.38	25.72	24.03	22.36	20.74	19.21
82.00	25.54	24.35	23.14	21.93	20.72	19.53
100.00	23.79	22.82	21.84	20.88	19.93	18.99
107.00	15.00	13.31	11.97	10.89	10.00	9.25
132.00	16.68	14.88	13.30	11.94	10.76	9.75
182.00	15.07	14.05	13.00	11.98	10.99	10.08
232.00	13.40	12.74	12.04	11.33	10.62	9.91
300.00	12.13	11.63	11.11	10.57	10.04	9.49

Source: DTN: MO0010MWDANS03.005

Table XXV-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 5 m³/s (50-100 Years), and 2.5 m³/s (100-300 Years) (Drift Spacing = 81 m, Waste Aged for Additional 18 Years)

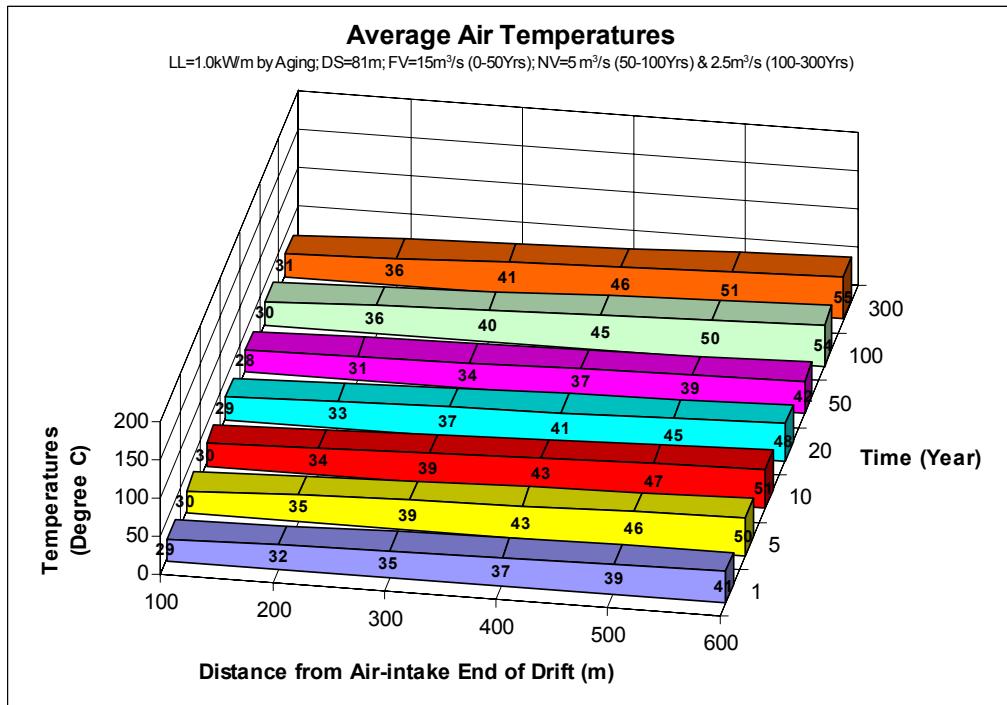
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)			
1.00E-04	68.63%	597.08	597.08	1.88	1.00E-04	214.72	107.36	0.34			
2.00	66.23%	576.22	586.65	36999.34	2.00	215.39	215.05	13563.19			
7.00	60.83%	529.22	552.72	87153.06	7.00	339.54	277.46	43750.50			
12.00	56.11%	488.18	508.70	80211.84	12.00	356.34	347.94	54863.12			
17.00	51.98%	452.19	470.18	74138.40	17.00	341.83	349.08	55043.39			
22.00	48.24%	419.68	435.94	68738.45	22.00	321.61	331.72	52305.55			
27.00	44.88%	390.42	405.05	63868.36	27.00	301.73	311.67	49144.59			
32.00	41.94%	364.89	377.65	59548.34	32.00	283.30	292.52	46124.03			
42.00	36.88%	320.81	342.85	108121.88	42.00	261.31	272.31	85874.62			
50.00	34.32%	298.60	309.71	78135.62	50.00	239.16	250.24	63131.54			
57.00	31.03%	269.93	284.27	62752.22	57.00	104.74	171.95	37957.96			
62.00	29.47%	256.40	263.17	41495.98	62.00	133.77	119.26	18804.26			
72.00	26.76%	232.84	244.62	77142.91	72.00	139.44	136.60	43079.70			
82.00	24.52%	213.32	223.08	70349.62	82.00	135.19	137.31	43303.23			
100.00	22.50%	195.73	204.52	116096.67	100.00	128.25	131.72	74770.82			
107.00	21.21%	184.50	190.11	41967.72	107.00	70.42	99.33	21927.86			
132.00	17.89%	155.68	170.09	134098.48	132.00	77.31	73.86	58233.99			
182.00	14.85%	129.19	142.43	224589.03	182.00	75.18	76.24	120220.86			
232.00	13.03%	113.33	121.26	191201.22	232.00	70.05	72.61	114494.89			
300.00	11.44%	99.51	106.42	228211.77	300.00	64.97	67.51	144767.51			
Total heat generated in 50 years (GJ)				656917.17	Total heat removed in 50 years (GJ)			463800.88			
Total heat generated in 100 years (GJ)				1024754.57	Total heat removed in 100 years (GJ)			681716.84			
Total heat generated in 300 years (GJ)				1844822.79	Total heat removed in 300 years (GJ)			1141361.94			
Percentage of total heat removal in 50 years = 71%											
Percentage of total heat removal in 100 years = 67%											
Percentage of total heat removal in 300 years = 62%											

Source: DTN: MO0010MWDANS03.005



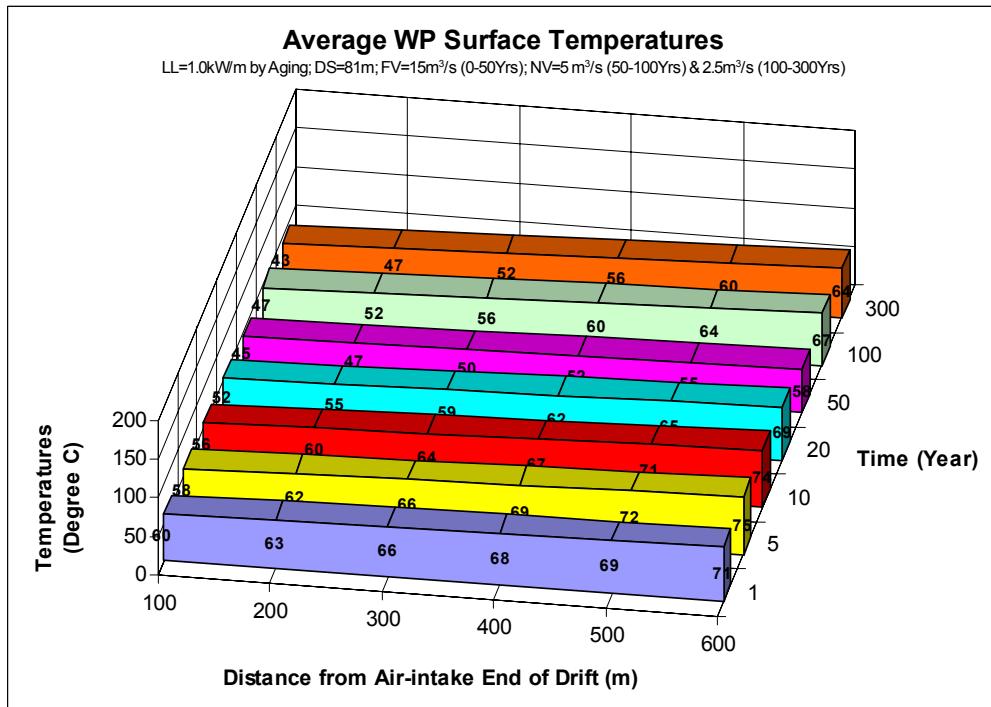
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXV-1, p. XXV-2.

Figure XXV-1. Average Drift Wall Temperatures for Case 24: HF5N5V8A



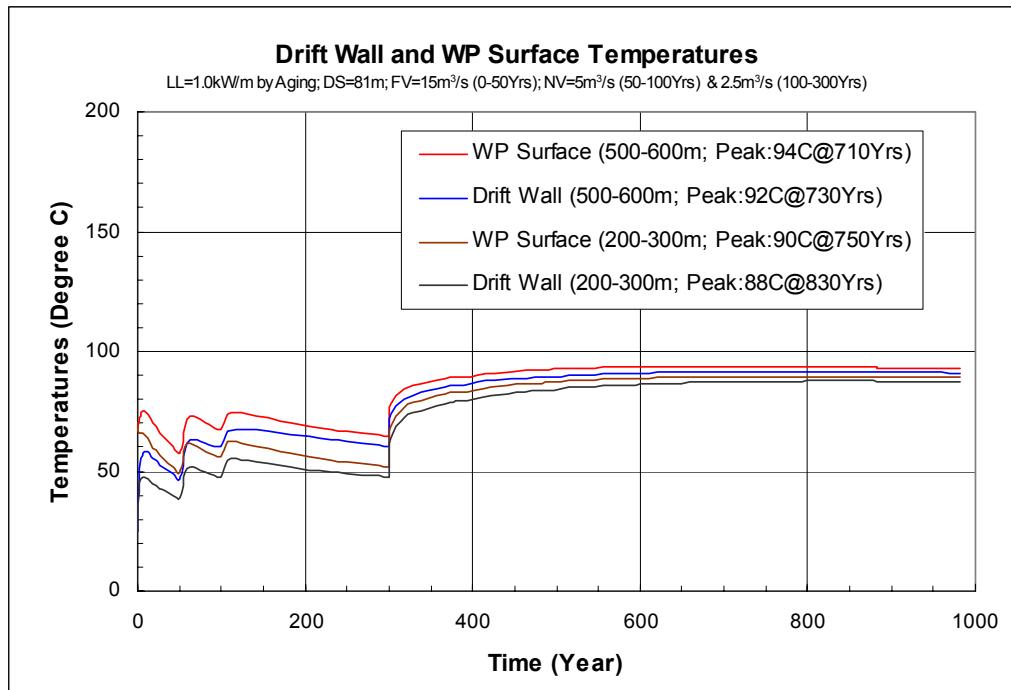
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXV-2, p. XXV-3.

Figure XXV-2. Average Air Temperatures for Case 24: HF5N5V8A



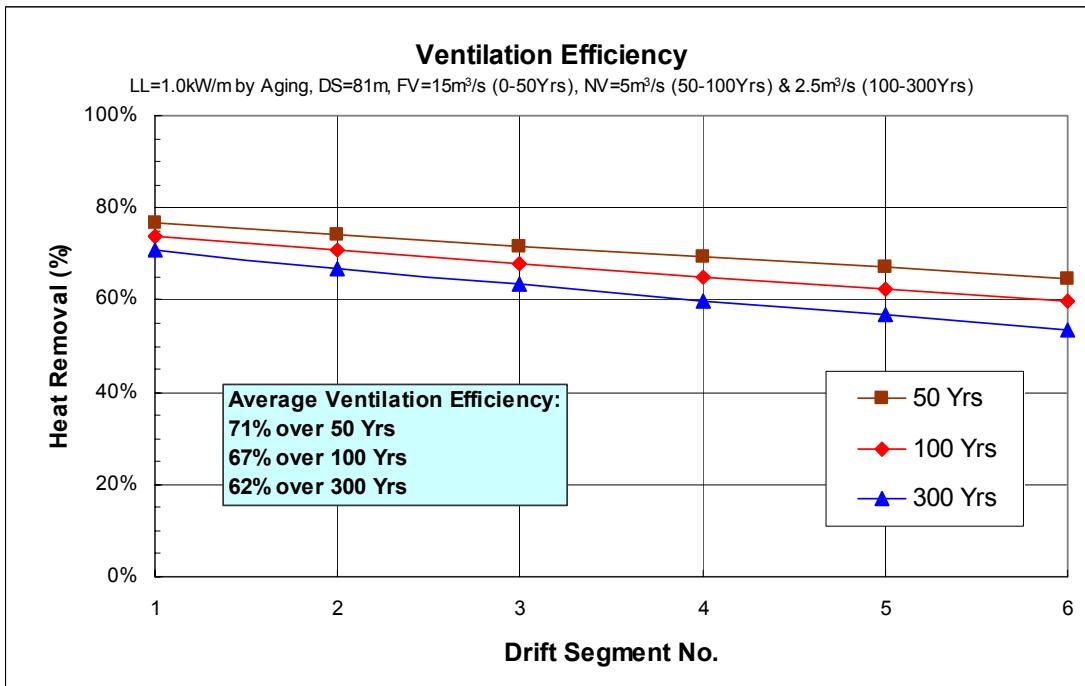
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXV-3, p. XXV-4.

Figure XXV-3. Average Waste Package Surface Temperatures for Case 24: HF5N5V8A



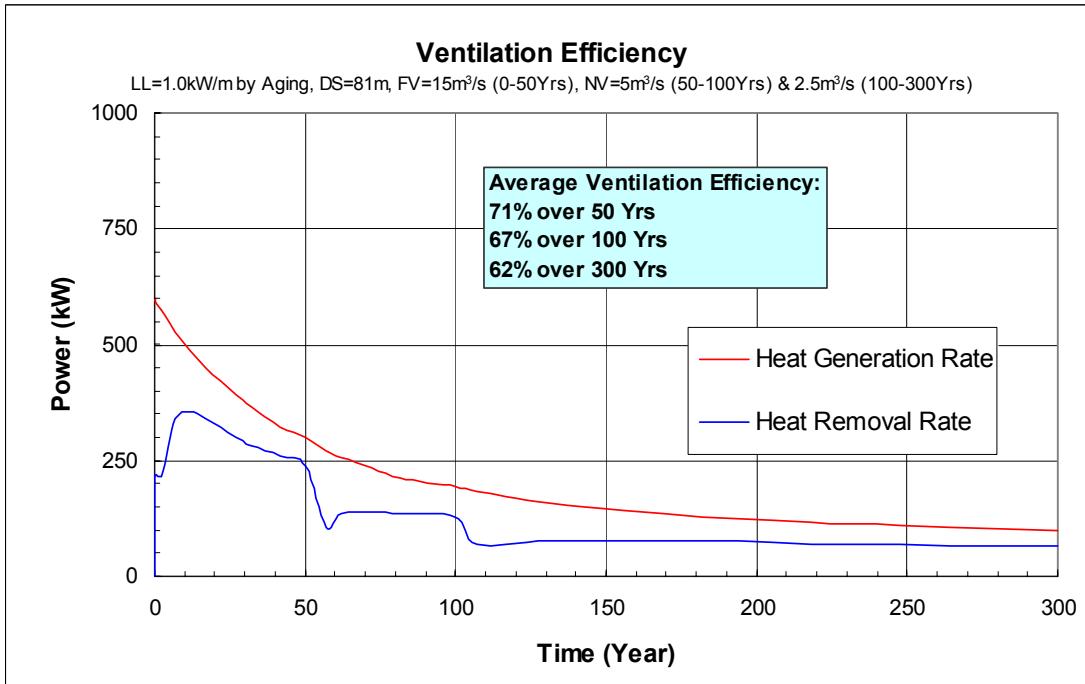
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXV-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 24: HF5N5V8A



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXV-5. Average Heat Removal Rates at Different Drift Segments for Case 24: HF5N5V8A



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXV-6. Overall Heat Generation and Removal Rates at Different Time for Case 24: HF5N5V8A

ATTACHMENT XXVI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 25: HF5N3VI8

ATTACHMENT XXVI

TEMPERATURES AND HEAT REMOVAL RATES FOR CASE 25: HF5N3VI8

This attachment provides the results of calculations of temperatures and ventilation efficiency (heat removed) for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 3 m³/s from 50 to 100 years, 1.5 m³/s from 100 to 300 years, and 1.0 m³/s from 300 to 10,000 years. Drift spacing for this case is 81 m. Ventilation efficiency is calculated for up to 10,000 years. All data presented in this attachment are obtained from DTN: MO0103MWDTEM00.007.

Table XXVI-1. Average Drift Wall Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), 1.5 m³/s (100-300 Years), and 1.0 m³/s (300-10,000 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	25.22	25.22	25.22	25.22	25.22	25.22
1.00	46.13	49.92	53.10	55.75	57.97	59.83
5.00	45.44	51.65	57.34	62.51	67.16	71.37
10.00	43.77	49.80	55.63	61.24	66.61	71.70
15.00	42.19	47.78	53.26	58.62	63.84	68.91
20.00	40.86	46.04	51.14	56.14	61.04	65.85
26.00	39.42	44.21	48.91	53.56	58.13	62.61
30.00	38.54	42.99	47.39	51.71	55.98	60.17
40.00	36.70	40.74	44.75	48.71	52.63	56.50
50.00	35.20	38.75	42.29	45.82	49.33	52.83
60.00	52.38	58.24	63.32	67.80	71.84	75.52
70.00	52.57	60.53	67.43	73.43	78.70	83.35
80.00	50.58	58.56	65.79	72.31	78.16	83.42
90.00	48.79	56.40	63.41	69.84	75.73	81.12
100.00	47.24	54.47	61.17	67.38	73.13	78.43
125.00	53.31	61.15	67.98	73.99	79.35	84.16
150.00	51.00	59.40	66.69	73.06	78.64	83.57
200.00	48.01	56.07	63.28	69.70	75.41	80.49
250.00	46.04	53.60	60.48	66.72	72.36	77.44
300.00	44.57	51.74	58.33	64.36	69.86	74.87
400.00	46.07	53.43	59.96	65.81	71.06	75.80
500.00	44.66	52.14	58.80	64.74	70.06	74.81
600.00	43.19	50.41	56.95	62.87	68.20	73.01
700.00	41.88	48.77	55.10	60.89	66.16	70.96
800.00	40.62	47.17	53.25	58.87	64.04	68.77
900.00	39.50	45.71	51.53	56.96	61.98	66.63
1000.00	38.56	44.45	50.01	55.23	60.11	64.64
1500.00	35.02	40.10	45.04	49.81	54.37	58.68
2000.00	32.95	37.01	41.12	45.20	49.22	53.12
3000.00	31.04	34.14	37.34	40.59	43.87	47.14
4000.00	30.25	32.74	35.27	37.85	40.47	43.13
5000.00	29.78	31.94	34.09	36.24	38.39	40.56
6000.00	29.45	31.42	33.33	35.21	37.07	38.92
7000.00	29.15	30.96	32.72	34.43	36.09	37.71
8000.00	28.90	30.60	32.22	33.80	35.32	36.80
9000.00	28.68	30.27	31.79	33.26	34.68	36.04
10000.00	28.47	29.97	31.40	32.78	34.11	35.38

Source: DTN: MO0103MWDTEM00.007

Table XXVI-2. Average Air Temperatures ($^{\circ}\text{C}$) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m^3/s (0-50 Years), 3 m^3/s (50-100 Years), 1.5 m^3/s (100-300 Years), and 1.0 m^3/s (300-10,000 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	25.00	25.00	25.00	25.00	25.00	25.00
1.00E-04	27.59	27.59	27.59	27.59	27.59	27.59
1.00	29.88	33.97	37.39	40.25	42.64	44.64
5.00	32.05	38.53	44.44	49.79	54.62	58.95
10.00	31.61	38.04	44.25	50.22	55.90	61.27
15.00	31.06	37.02	42.86	48.57	54.14	59.55
20.00	30.58	36.08	41.49	46.80	52.02	57.14
26.00	30.13	35.18	40.17	45.09	49.93	54.70
30.00	29.74	34.43	39.05	43.61	48.11	52.55
40.00	29.29	33.55	37.77	41.95	46.08	50.17
50.00	28.73	32.46	36.19	39.90	43.60	47.28
60.00	32.88	39.58	45.39	50.53	55.15	59.38
70.00	35.94	45.39	53.55	60.63	66.81	72.24
80.00	35.51	45.06	53.68	61.42	68.35	74.55
90.00	34.75	43.76	52.05	59.66	66.62	72.97
100.00	34.08	42.53	50.38	57.65	64.38	70.59
125.00	36.34	46.06	54.52	61.97	68.61	74.57
150.00	37.02	47.39	56.35	64.13	70.93	76.91
200.00	35.81	45.52	54.18	61.88	68.71	74.76
250.00	34.70	43.59	51.69	59.03	65.67	71.65
300.00	33.93	42.19	49.79	56.77	63.15	68.96
400.00	34.78	43.38	51.03	57.88	64.04	69.60
500.00	34.74	43.40	51.09	57.95	64.07	69.56
600.00	34.03	42.27	49.75	56.51	62.60	68.08
700.00	33.35	41.10	48.23	54.77	60.74	66.16
800.00	32.73	39.99	46.76	53.03	58.81	64.12
900.00	32.16	38.96	45.36	51.35	56.92	62.08
1000.00	31.67	38.04	44.10	49.81	55.17	60.17
1500.00	30.60	36.14	41.54	46.75	51.73	56.45
2000.00	29.26	33.66	38.12	42.55	46.92	51.17
3000.00	28.32	31.76	35.29	38.89	42.50	46.11
4000.00	27.69	30.42	33.21	36.06	38.95	41.88
5000.00	27.39	29.75	32.10	34.45	36.82	39.21
6000.00	27.20	29.34	31.42	33.48	35.51	37.53
7000.00	27.05	29.02	30.94	32.79	34.60	36.38
8000.00	26.92	28.76	30.53	32.25	33.90	35.51
9000.00	26.80	28.53	30.19	31.79	33.33	34.81
10000.00	26.70	28.33	29.89	31.39	32.83	34.21

Source: DTN: MO0103MWDTEM00.007

Table XXVI-3. Average Waste Package Surface Temperatures (°C) at Different Time and Locations during Ventilation for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), 1.5 m³/s (100-300 Years), and 1.0 m³/s (300-10,000 Years) (Drift Spacing = 81 m)

Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	70.00	70.00	70.00	70.00	70.00	70.00
1.00E-04	68.02	68.02	68.02	68.02	68.02	68.02
1.00	74.51	77.86	80.67	83.03	85.00	86.65
5.00	71.27	76.70	81.70	86.26	90.37	94.10
10.00	67.48	72.76	77.91	82.89	87.68	92.24
15.00	64.11	69.05	73.92	78.70	83.38	87.95
20.00	61.25	65.87	70.43	74.92	79.34	83.69
26.00	58.14	62.45	66.70	70.90	75.05	79.14
30.00	56.25	60.27	64.26	68.19	72.08	75.92
40.00	52.18	55.88	59.56	63.21	66.83	70.41
50.00	48.85	52.13	55.41	58.69	61.96	65.22
60.00	65.54	70.98	75.69	79.86	83.61	87.04
70.00	64.13	71.61	78.13	83.80	88.78	93.19
80.00	61.09	68.63	75.48	81.67	87.25	92.27
90.00	58.47	65.69	72.35	78.48	84.11	89.27
100.00	56.22	63.10	69.49	75.43	80.93	86.03
125.00	61.20	68.71	75.26	81.04	86.19	90.83
150.00	57.72	65.83	72.90	79.06	84.47	89.25
200.00	53.67	61.49	68.50	74.75	80.33	85.28
250.00	51.07	58.42	65.13	71.22	76.73	81.70
300.00	49.15	56.14	62.57	68.46	73.85	78.77
400.00	50.03	57.23	63.63	69.36	74.51	79.16
500.00	48.10	55.44	61.99	67.84	73.07	77.75
600.00	46.24	53.34	59.78	65.61	70.88	75.62
700.00	44.62	51.40	57.65	63.36	68.57	73.31
800.00	43.09	49.54	55.55	61.10	66.21	70.89
900.00	41.74	47.87	53.62	58.98	63.96	68.56
1000.00	40.62	46.44	51.93	57.10	61.93	66.42
1500.00	36.46	41.49	46.40	51.14	55.66	59.96
2000.00	34.10	38.13	42.20	46.27	50.26	54.15
3000.00	31.97	35.05	38.23	41.47	44.74	48.00
4000.00	31.10	33.58	36.10	38.66	41.28	43.92
5000.00	30.57	32.72	34.86	37.00	39.15	41.31
6000.00	30.19	32.15	34.06	35.94	37.79	39.63
7000.00	29.83	31.65	33.40	35.11	36.76	38.39
8000.00	29.54	31.24	32.87	34.44	35.96	37.43
9000.00	29.28	30.87	32.40	33.87	35.28	36.65
10000.00	29.03	30.53	31.97	33.35	34.68	35.95

Source: DTN: MO0103MWDTEM00.007

Table XXVI-4. Heat Removed (kW) by Ventilation at Different Time and Locations for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), 1.5 m³/s (100-300 Years), and 1.0 m³/s (300-10,000 Years)
(Drift Spacing = 81 m)

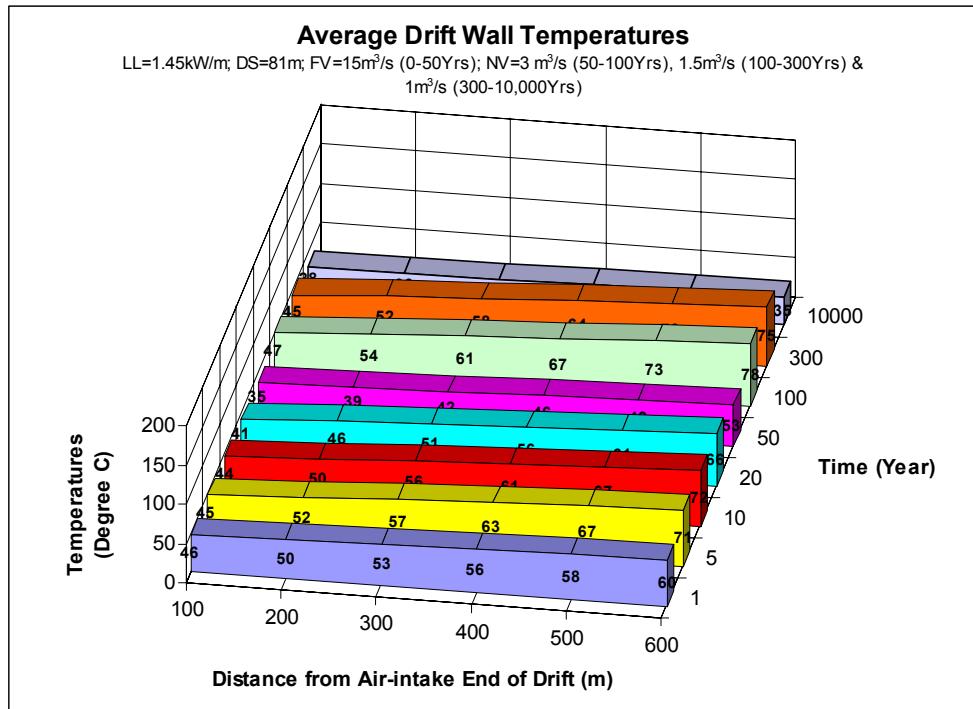
Time (Year)	Location Measured from Air-intake End (m)					
	0-100	100-200	200-300	300-400	400-500	500-600
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00E-04	35.80	35.80	35.80	35.80	35.80	35.80
1.00	67.58	56.52	47.28	39.54	33.07	27.66
5.00	97.57	89.60	81.73	74.09	66.79	59.96
10.00	91.39	88.99	86.00	82.48	78.58	74.41
15.00	83.89	82.39	80.79	79.00	77.04	74.86
20.00	77.25	76.03	74.82	73.55	72.21	70.81
26.00	70.92	69.98	69.01	68.02	67.00	65.94
30.00	65.62	64.80	63.96	63.12	62.26	61.38
40.00	59.35	58.88	58.38	57.82	57.23	56.59
50.00	51.62	51.61	51.53	51.39	51.17	50.90
60.00	20.56	17.49	15.16	13.40	12.06	11.03
70.00	28.55	24.65	21.30	18.48	16.12	14.17
80.00	27.42	24.93	22.50	20.20	18.08	16.16
90.00	25.44	23.51	21.64	19.86	18.16	16.56
100.00	23.70	22.05	20.48	18.97	17.55	16.20
125.00	14.30	12.25	10.66	9.39	8.37	7.51
150.00	15.15	13.06	11.29	9.81	8.57	7.53
200.00	13.63	12.24	10.92	9.70	8.60	7.63
250.00	12.22	11.20	10.21	9.26	8.36	7.53
300.00	11.25	10.41	9.59	8.79	8.04	7.33
400.00	8.00	7.04	6.26	5.60	5.04	4.55
500.00	7.97	7.08	6.30	5.61	5.01	4.49
600.00	7.39	6.74	6.12	5.53	4.98	4.48
700.00	6.83	6.34	5.84	5.35	4.88	4.44
800.00	6.33	5.94	5.54	5.13	4.73	4.34
900.00	5.86	5.56	5.24	4.90	4.56	4.22
1000.00	5.45	5.22	4.95	4.67	4.38	4.09
1500.00	4.58	4.53	4.42	4.26	4.07	3.86
2000.00	3.49	3.60	3.64	3.63	3.57	3.47
3000.00	2.72	2.81	2.89	2.94	2.96	2.95
4000.00	2.20	2.24	2.28	2.33	2.37	2.39
5000.00	1.95	1.93	1.92	1.93	1.94	1.95
6000.00	1.80	1.75	1.71	1.68	1.66	1.65
7000.00	1.68	1.62	1.56	1.52	1.48	1.45
8000.00	1.57	1.51	1.45	1.40	1.36	1.31
9000.00	1.48	1.42	1.36	1.31	1.26	1.21
10000.00	1.39	1.33	1.28	1.23	1.18	1.13

Source: DTN: MO0103MWDTEM00.007

Table XXVI-5. Calculation of Overall Ventilation Efficiency for 600m-long Drift for 1.45 kW/m, 15 m³/s (0-50 Years), 3 m³/s (50-100 Years), 1.5 m³/s (100-300 Years), and 1.0 m³/s (300-10,000 Years) (Drift Spacing = 81 m)

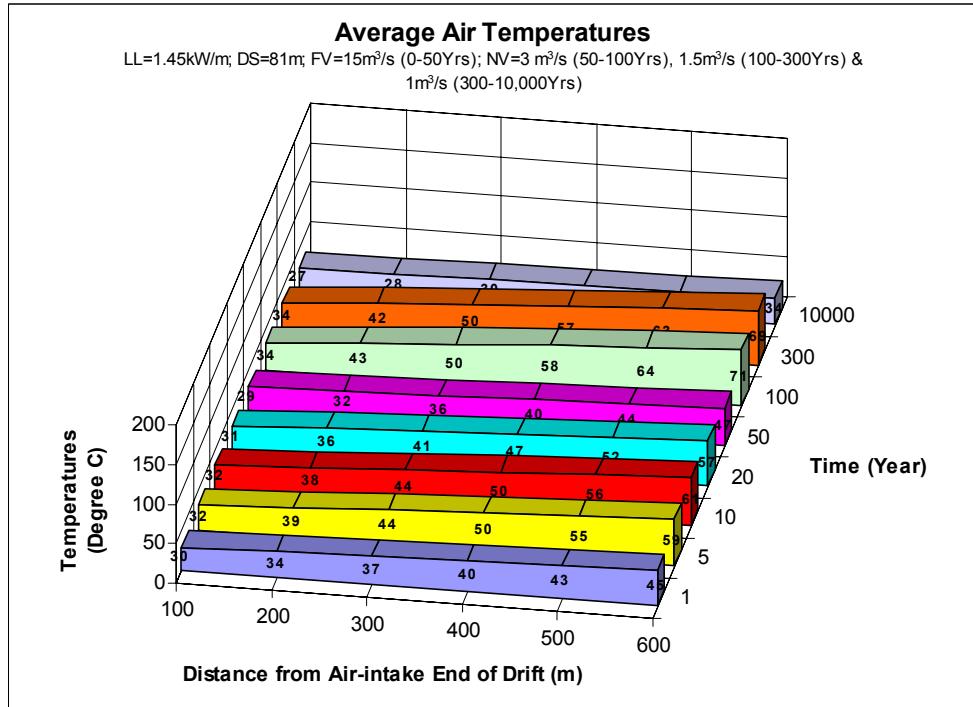
Time (year)	% of Heat Decay	Rate of Heat Generated per 600m (kW)	Average Rate of Heat Generated per 600m (kW)	Heat Generated per 600m (GJ)	Time (year)	Rate of Heat Removed per 600m (kW)	Average Rate of Heat Removed per 600m (kW)	Heat Removed per 600m (GJ)				
1.00E-04	100.00%	870.00	870.00	2.74	1.00E-04	214.82	107.41	0.34				
1.00	96.99%	843.84	856.92	27021.20	1.00	271.66	243.24	7670.07				
5.00	87.93%	764.96	804.40	101470.60	5.00	469.74	370.70	46761.31				
10.00	79.35%	690.37	727.67	114738.26	10.00	501.84	485.79	76599.37				
15.00	72.23%	628.43	659.40	103973.79	15.00	477.97	489.91	77248.24				
20.00	66.23%	576.22	602.32	94974.15	20.00	444.67	461.32	72740.48				
26.00	59.89%	521.01	548.62	103807.02	26.00	410.86	427.76	80939.32				
30.00	56.11%	488.18	504.60	63651.70	30.00	381.14	396.00	49952.75				
40.00	48.24%	419.68	453.93	143151.62	40.00	348.25	364.69	115009.73				
50.00	41.94%	364.89	392.29	123711.69	50.00	308.23	328.24	103513.19				
60.00	36.88%	320.81	342.85	108121.88	60.00	89.70	198.96	62745.18				
70.00	32.81%	285.42	303.12	95590.81	70.00	123.26	106.48	33579.91				
80.00	29.47%	256.40	270.91	85434.15	80.00	129.28	126.27	39821.71				
90.00	26.76%	232.84	244.62	77142.91	90.00	125.18	127.23	40123.27				
100.00	24.52%	213.32	223.08	70349.62	100.00	118.95	122.06	38493.67				
125.00	21.21%	184.50	198.91	156819.84	125.00	62.48	90.71	71518.35				
150.00	17.89%	155.68	170.09	134098.48	150.00	65.42	63.95	50415.54				
200.00	14.85%	129.19	142.43	224589.03	200.00	62.71	64.06	101016.39				
250.00	13.03%	113.33	121.26	191201.22	250.00	58.79	60.75	95789.35				
300.00	11.76%	102.34	107.84	170036.07	300.00	55.41	57.10	90029.43				
400.00	9.97%	86.72	94.53	298108.41	400.00	36.48	45.95	144892.64				
500.00	8.66%	75.37	81.04	255582.09	500.00	36.45	36.47	115000.25				
600.00	7.65%	66.56	70.96	223793.02	600.00	35.24	35.84	113039.48				
700.00	6.83%	59.40	62.98	198605.64	700.00	33.67	34.45	108654.57				
800.00	6.14%	53.44	56.42	177916.80	800.00	32.00	32.83	103544.96				
900.00	5.55%	48.29	50.86	160400.50	900.00	30.33	31.17	98285.13				
1000.00	5.08%	44.19	46.24	145814.38	1000.00	28.77	29.55	93187.17				
1500.00	3.50%	30.43	37.31	588256.69	1500.00	25.73	27.25	429630.68				
2000.00	2.75%	23.91	27.17	428406.28	2000.00	21.40	23.57	371581.29				
3000.00	2.16%	18.75	21.33	672745.04	3000.00	17.27	19.33	609740.13				
4000.00	1.94%	16.87	17.81	561711.61	4000.00	13.81	15.54	489950.95				
5000.00	1.78%	15.53	16.20	510817.50	5000.00	11.62	12.71	400969.74				
6000.00	1.67%	14.50	15.01	473433.41	6000.00	10.25	10.93	344831.70				
7000.00	1.55%	13.45	13.97	440617.49	7000.00	9.31	9.78	308361.68				
8000.00	1.45%	12.60	13.02	410699.84	8000.00	8.60	8.95	282351.85				
9000.00	1.36%	11.83	12.21	385200.43	9000.00	8.03	8.31	262144.98				
10000.00	1.28%	11.10	11.46	361495.39	10000.00	7.54	7.78	245433.97				
Total heat generated in 50 years (GJ)				876502.77	Total heat removed in 50 years (GJ)		630434.80					
Total heat generated in 100 years (GJ)				1313142.14	Total heat removed in 100 years (GJ)		845198.54					
Total heat generated in 300 years (GJ)				2189886.77	Total heat removed in 300 years (GJ)		1253967.61					
Total heat generated in 10,000 years (GJ)				8483491.29	Total heat removed in 10,000 years (GJ)		5775568.76					
Percentage of total heat removal in 50 years = 72%												
Percentage of total heat removal in 100 years = 64%												
Percentage of total heat removal in 300 years = 57%												
Percentage of total heat removal in 10,000 years = 68%												

Source: DTN: MO0103MWDTEM00.007



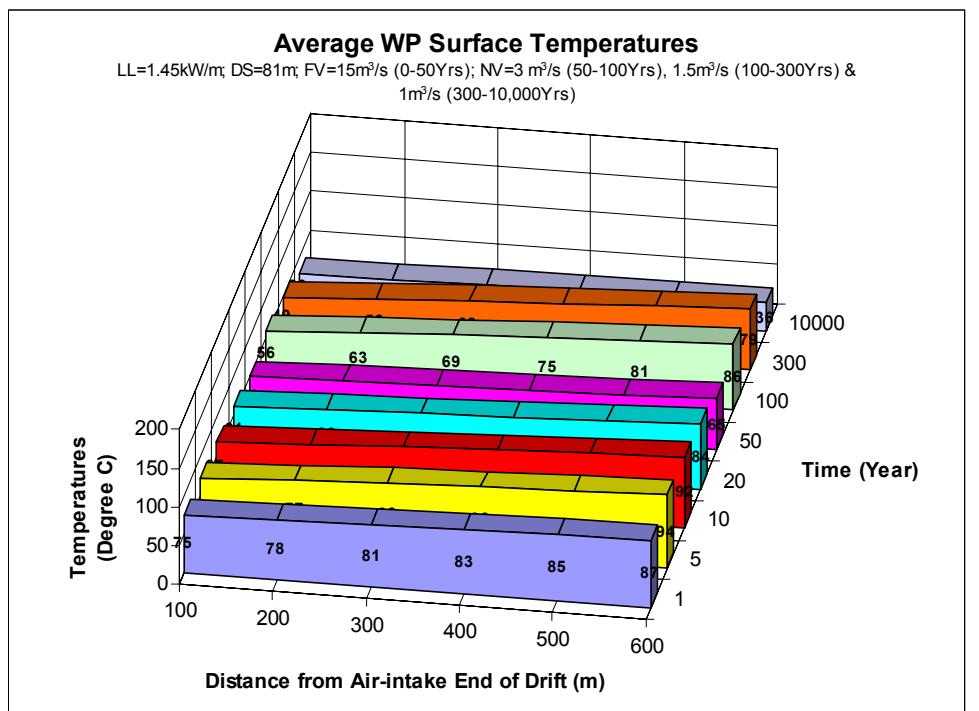
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXVI-1, p. XXVI-3.

Figure XXVI-1. Average Drift Wall Temperatures for Case 25: HF5N3VI8



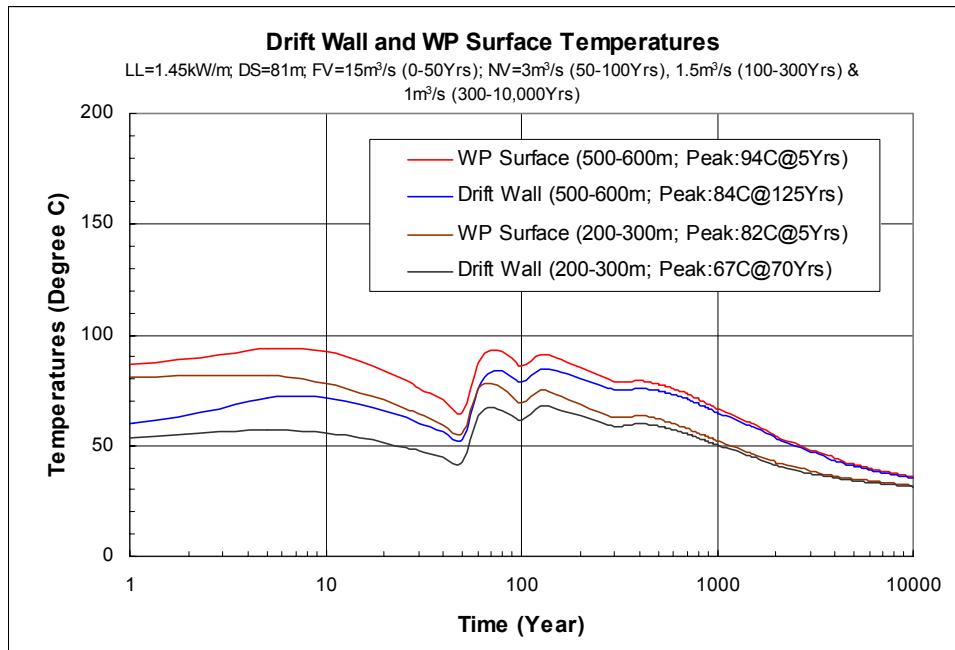
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXVI-2, p. XXVI-4.

Figure XXVI-2. Average Air Temperatures for Case 25: HF5N3VI8



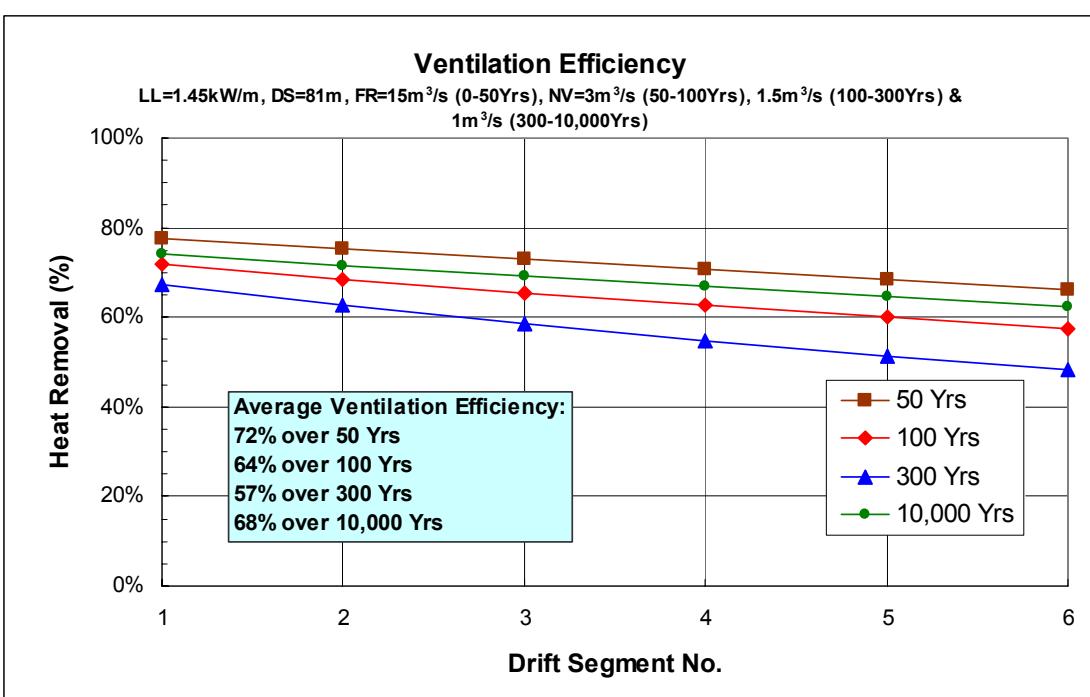
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.
For obliterated numbers, see Table XXVI-3, p. XXVI-5.

Figure XXVI-3. Average Waste Package Surface Temperatures for Case 25: HF5N3VI8



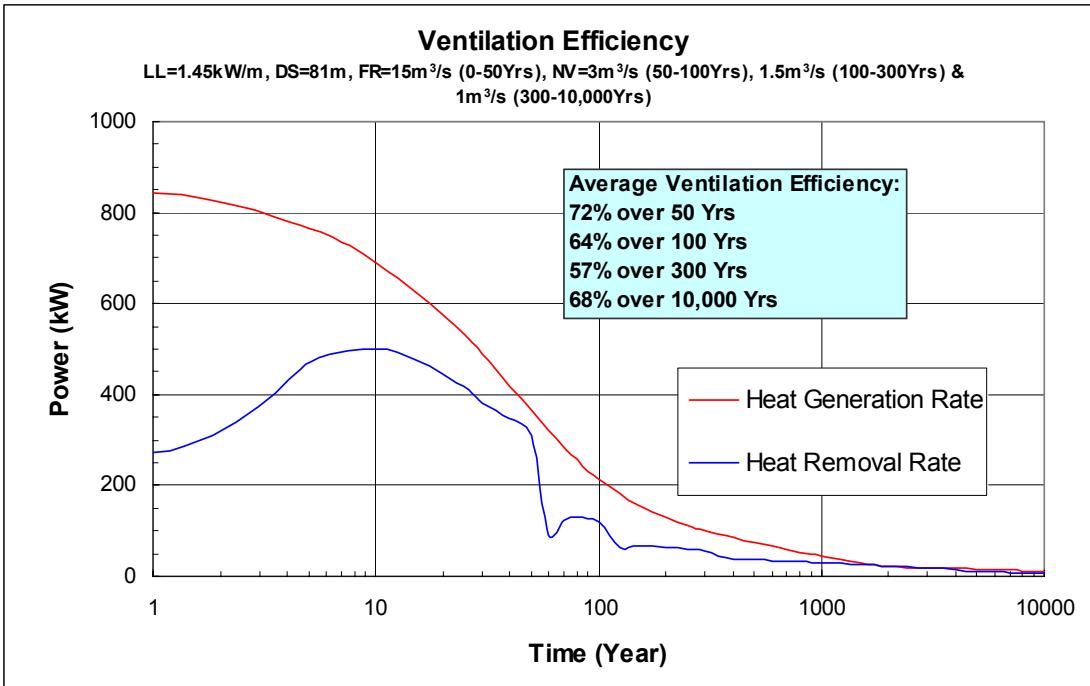
Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXVI-4. Average Drift Wall and Waste Package Surface Temperatures at Different Time and Locations for Case 25: HF5N3VI8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXVI-5. Average Heat Removal Rates at Different Drift Segments for Case 25: HF5N3VI8



Note: LL=Initial Linear Heat Load; DS=Drift Spacing; FV=Forced Ventilation; NV=Natural Ventilation.

Figure XXVI-6. Overall Heat Generation and Removal Rates at Different Time for Case 25: HF5N3VI8

ATTACHMENT XXVII

CALCULATION OF IN-DRIFT RELATIVE HUMIDITY FOR CASE 25: HF5N3VI8

ATTACHMENT XXVII

CALCULATION OF IN-DRIFT RELATIVE HUMIDITY FOR CASE 25: HF5N3VI8

This attachment provides the results of calculations of in-drift relative humidity for a linear heat load of 1.45 kW/m with a forced ventilation air flow rate of 15 m³/s from 0 to 50 years and natural ventilation air flow rates of 3 m³/s from 50 to 100 years, 1.5 m³/s from 100 to 300 years, and 1.0 m³/s from 300 to 10,000 years. Drift spacing for this case is 81 m. All data presented in this attachment are obtained from DTN: MO0103MWDTEM00.007.

The calculation used an average inlet air of 25°C dry bulb temperature at 30 percent relative humidity (see Section 5.3.2). The ventilation air is allowed to cross the emplacement drift picking up the heat of the waste packages and all the potential moisture influx of 60 mm per year, inclusive of the 600-m long emplacement drift aerial footprint.

Table XXVII-1 is a psychrometric calculation showing various potential temperatures and humidities of intake air in the emplacement drift. The table headings are described further with nomenclature and equations below. The formulas or equations used are taken from *Mine Ventilation and Air Conditioning* (Hartman et al. 1997, pp. 12 to 18). Table XXVII-1 shows the specific psychrometric properties of the intake air at typical 25°C dry bulb temperature and 30 percent relative humidity in the repository horizon.

The same psychrometric calculation is applied to Tables XXVII-2 and XXVII-3 using various dry bulb air temperatures of ANSYS output and moisture mass present in the ventilation air as a result of water influx from the rock formation.

Calculations are converted to English Units by using the reference material equations or formulas for air psychrometry and conversion factors from *Mine Ventilation and Air Conditioning* (Hartman et al. 1997, pp. 12 to 18) and *Perry's Chemical Engineers' Handbook* (Perry and Green 1984, Table 1-5).

Calculation of water influx rate into the emplacement drift

- (1). Drift aerial configuration is 600 m × 5.5 m or approximately 2,000 ft × 18 ft for a total area of 36,000 ft².
- (2). Conversion of total water influx at 60 mm/year is 2.362 inches/yr or 0.19685 ft/yr.
- (3). Total annual water volume in emplacement drift is 36,000 ft² × 0.19685 ft/yr or 7,086.600 ft³/yr.
- (4). Total annual mass of water in emplacement drift is 7,086.600 ft³/yr × 62.4 lb/ ft³ or 442,203.84 lb/yr
- (5). Conversion rate of water influx to lb/min or grains/min at 100 percent evaporation is
442,203.84 lb/yr / 365 days/yr / 24 hr/day / 60 min/hr or 0.84133 lb/min

At 7,000 grains per pound,

Total water (moisture) influx rate to air is $0.84133 \text{ lb/min} \times 7,000 \text{ grains/lb} = 5,889.31 \text{ grains/min}$, using the conversion factor from *Perry's Chemical Engineers' Handbook* (Perry and Green 1984, Table 1-5).

Mass of Moisture in Emplacement Drift Air

- (1). The inlet air is 77°F (25°C) dry bulb temperature at 30 percent relative humidity. The calculated psychrometric properties of the inlet air is shown in Table XXVII-1. For Case 4, Column M shows the inlet air has initial moisture content of 47.25 grains/lb air.
- (2). The inlet air specific volume is 15.633 ft³/lb as shown in Table XXVII-1, Column N, for Case 4.
- (3). At an air volume conversion rate of $1 \text{ m}^3/\text{s} = 2,118.644 \text{ ft}^3/\text{min}$, the mass equivalent flow rate of air and moisture in the emplacement drift are as follows:

a) Air Quantity @ $15 \text{ m}^3/\text{s} = 2,118.644 \text{ ft}^3/\text{min}/(\text{m}^3/\text{s}) \times 15 \text{ m}^3/\text{s} = 31,779.66 \text{ ft}^3/\text{min}$

$$\text{Air Mass} = 31,779.66 \text{ ft}^3/\text{min} / 15.633 \text{ ft}^3/\text{lb} = 2032.857 \text{ lb/min}$$

Total moisture rate added by water influx is 5,889.31 grains/min

Average distribution of added moisture in mass of air,

$$5,889.31 \text{ grains/min} / 2,032.857 \text{ lb/min} = 2.897 \text{ grains/lb}$$

New total moisture content of air = initial + water influx

$$= 47.25 \text{ grains/lb} + 2.897 \text{ grains/lb} = 50.15 \text{ grains/lb.}$$

b) Air Quantity @ $3 \text{ m}^3/\text{s} = 2,118.644 \text{ ft}^3/\text{min}/(\text{m}^3/\text{s}) \times 3 \text{ m}^3/\text{s} = 6,355.93 \text{ ft}^3/\text{min}$

$$\text{Air Mass} = 6,355.93 \text{ ft}^3/\text{min} / 15.633 \text{ ft}^3/\text{lb} = 406.571 \text{ lb/min}$$

Total moisture rate added by water influx is 5,889.31 grains/min

Average distribution of added moisture in mass of air,

$$5,889.31 \text{ grains/min} / 406.571 \text{ lb/min} = 14.485 \text{ grains/lb}$$

New total moisture content of air = initial + water influx

$$= 47.25 \text{ grains/lb} + 14.485 \text{ grains/lb} = 61.738 \text{ grains/lb.}$$

c) Air Quantity @ $1.5 \text{ m}^3/\text{s} = 2,118.644 \text{ ft}^3/\text{min}/(\text{m}^3/\text{s}) \times 1.5 \text{ m}^3/\text{s} = 3,177.97 \text{ ft}^3/\text{min}$

$$\text{Air Mass} = 3,177.97 \text{ ft}^3/\text{min} / 15.633 \text{ ft}^3/\text{lb} = 203.286 \text{ lb/min}$$

Total moisture rate added by water influx is 5,889.31 grains/min

Average distribution of added moisture in mass of air,

$$5,889.31 \text{ grains/min} / 203.286 \text{ lb/min} = 28.971 \text{ grains/lb}$$

New total moisture content of air = initial + water influx

$$= 47.25 \text{ grains/lb} + 28.971 \text{ grains/lb} = 76.224 \text{ grains/lb.}$$

d) Air Quantity @ 1.0 m³/s = 2,118.644 ft³/min/(m³/s) × 1.0 m³/s = 2,118.64 ft³/min

$$\text{Air Mass} - 2,118.64 \text{ ft}^3/\text{min} / 15.633 \text{ ft}^3/\text{lb} = 135.524 \text{ lb/min}$$

Total moisture rate added by water influx is 5,889.31 grains/min

Average distribution of added moisture in mass of air,

$$5,889.31 \text{ grains/min} / 135.524 \text{ lb/min} = 43.456 \text{ grains/lb}$$

New total moisture content of air = initial + water influx

$$= 47.25 \text{ grains/lb} + 43.456 \text{ grains/lb} = 90.709 \text{ grains/lb.}$$

- (4). Given the mass content of moisture in the exhaust air, in grains per pound, the relative humidity is calculated through the equations and formulas shown in Table XXVII-1. This is based on the calculated dry bulb temperatures using ANSYS, as shown in Column D of Tables XXVII-2 and XXVII-3.
- (5). Table XXVII-2, Column K data are calculated relative humidity predictions in the next 10,000 years of preclosure and postclosure repository ventilation. The calculation is based on the water influx of 60 mm per year into the emplacement drift.

Effects of Moisture on Predicted Thermal Response

The thermal prediction of emplacement drift climate through ANSYS simulation considers only the case when there is no moisture influx from the rock formation. ANSYS calculates the dry bulb temperature of the air in the emplacement drift. The moisture mass in the ventilation air crossing the entire 600-m long emplacement drift is constant.

Since this calculation has included the change in the moisture mass of the ventilation air because of water influx from the rock formation, the simulation of ANSYS and the calculation of relative humidity have some degree of uncertainty.

The effects of moisture on the predicted thermal response is shown by enthalpy comparison of Tables XXVII-2 and XXVII-3, which show the total heat content of the ventilation air with and without the moisture influx. The comparison of enthalpy is focused on the ventilation air after it crosses the 600-m long emplacement drift. Column P of Table XXVII-2 is the enthalpy of ventilation air, including the water influx of 60 mm per year. With the same ANSYS simulation,

Column P of Table XXVII-3 is the enthalpy of the ventilation air with a constant initial moisture mass and no water influx.

Table XXVII-4 is the enthalpy comparison of both cases. The effects of moisture on the predicted thermal response are judged in terms of the percent difference between the two outputs as follows:

- (1). For ventilation air of $15 \text{ m}^3/\text{s}$ in 0-50 years, the difference is between 1.12 to 1.68 percent.
- (2). For ventilation air of $3 \text{ m}^3/\text{s}$ in 50-100 years, the difference is between 5.01 to 5.68 percent.
- (3). For ventilation air of $1.5 \text{ m}^3/\text{s}$ in 100-300 years, the difference is between 9.69 to 10.37 percent.
- (4). For ventilation air of $1.0 \text{ m}^3/\text{s}$ in 300-10,000 years, the difference is between 15.47 to 22.89 percent.

A curve relationship of the enthalpy difference (percent) versus the air quantity for all cases (10,000 years) is shown Figure XXVII-1. The difference associated with the temperature calculations using ANSYS simulation by neglecting the effects of moisture on the thermal response is small, especially within the first few hundred years of repository ventilation when the air quantity is between 15 and $1.5 \text{ m}^3/\text{s}$. The difference can become significant when the air quantity is $1.0 \text{ m}^3/\text{s}$ or less.

Table XXVII-1. Psychrometric Properties of Intake Ventilation Air in Emplacement Drift

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	M
		Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Density	Enthalpy		
Sample Intake Ventilation Air	Temp.	Temp.	Temp	Temp	Pres. Ave.	Pres. at Td	Pres. at Tw	Vapor Pressure	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.	Moisture	Moisture	
	Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H ₂ O)	W*7000	v	w	h	g/kg	W*7000	
	Equiv. of	Assumed	Adjusted	Equiv. Of	Assumed	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	
	Col D	Empl Air	to fit	Col. E	Ave Field											Col M x	
	Case		Intake	Col. K		Data										0.1429	
		°F	°C	°F	°C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hum.	lb/lb dry air	Grains/lb air	ft ³ /lb dry air	lb/ft ³	Btu/lb air	Gram/Kg	Grains/lb air
			Input °C	Adjusted Trial Number		Input "Hg				Desired Number							Calc Input
1		77.00	25	51.384	10.77	26.2	0.93763	0.38261	0.14064	15.00	0.00336	23.50	15.549	0.06452	22.155	3.36	23.50
2		77.00	25	53.331	11.85	26.2	0.93763	0.41107	0.18753	20.00	0.00448	31.39	15.577	0.06447	23.389	4.49	31.39
3		77.00	25	55.205	12.89	26.2	0.93763	0.44019	0.23440	25.00	0.00561	39.30	15.605	0.06443	24.626	5.62	39.30
4	Use this	77.00	25	57.011	13.90	26.2	0.93763	0.46996	0.28129	30.00	0.00675	47.25	15.633	0.06438	25.869	6.75	47.25
5		77.00	25	58.754	14.86	26.2	0.93763	0.50034	0.32817	35.00	0.00789	55.23	15.662	0.06434	27.116	7.89	55.23
6		77.00	25	60.436	15.80	26.2	0.93763	0.53128	0.37504	40.00	0.00903	63.23	15.690	0.06430	28.368	9.04	63.23
7		77.00	25	62.062	16.70	26.2	0.93763	0.56277	0.42193	45.00	0.01018	71.27	15.719	0.06425	29.624	10.18	71.27
8		77.00	25	63.634	17.57	26.2	0.93763	0.59476	0.46881	50.00	0.01133	79.33	15.747	0.06421	30.885	11.34	79.33
9		77.00	25	65.156	18.42	26.2	0.93763	0.62724	0.51569	55.00	0.01249	87.42	15.776	0.06417	32.151	12.49	87.42
10		80.00	26.668	59.150	15.08	26.2	1.03492	0.50748	0.31074	30.03	0.00747	52.26	15.739	0.06400	27.383	7.47	52.26

Note: T_d = temperature dry bulb, °F; T_w = temperature wet bulb, °F; P_b = barometric pressure, inch Hg.

Formulas used to determine characteristics of air are listed as follows (Hartman et al. 1997, pp. 12 to 18) and (Perry and Green 1984, Table 1-5):

Saturated Vapor Pressure (at T_d), $Ps = 0.18079 \times e^{(((17.27 \times T_d) - 552.64)/(T_d + 395.14))}$, inches Hg

Saturated Vapor Pressure (at T_w), $Ps' = 0.18079 \times e^{(((17.27 \times T_w) - 552.64)/(T_w + 395.14))}$, inches Hg

Vapor Pressure, $Pv = Ps' - ((Pb - Ps') \times (T_d - T_w))/(2800 - 1.3 \times T_w)$, inches Hg

Relative Humidity, $R = (Pv/Ps) \times 100\%$

Specific Humidity, $W = 0.622 \times (Pv/(Pb - Pv))$, lb/lb dry air, or

Grains Specific Humidity, $W \times 7000 = 0.622 \times (Pv/(Pb - Pv)) \times 7000$, grains water vapor/lb dry air

Specific Volume, $v = 53.35 \times (460 + T_d)/((Pb - Pv) \times 0.491 \times 144)$, ft³/lb

Moist Air density, $w = (1.325/(460 + T_d)) \times (Pb - .378 \times Pv)$, lb/ft³

Enthalpy, $h = 0.24 \times T_d + W \times (1060 + 0.45 \times T_d)$, Btu/lb dry air

Table XXVII-2. Psychrometric Properties of Ventilation Air in Emplacement Drift - at 600 m with Variable Moisture

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	M
	Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Density	Enthalpy			
Test Sta. & Remarks	Temp.	Temp.	Temp	Temp	Pres. Ave.	Pres. at Td	Pres. at Tw	Vapor Pres.	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.	Moisture	Moisture	
	Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H ₂ O)	W*7000	v	w	h	g/kg	W*7000	
	Equiv. of	Observed	Adjusted	Equiv. Of	Observed	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	input	
	Col D	Field	to fit	Col. E	Field											Col M x 0.1429	
Year	Air Quantity			Col. M													
	m ³ /s	°F	°C	°F	°C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hum.	lb/lb dry air	Grains/lb air	ft ³ /lb dry air	lb/ft ³	Btu/lb air	Gram/Kg	Grains/lb air
		Input ^oC			Input "Hg											Input	
		600m														600m	
0.0001	15	81.66	27.59	59.268	15.15	26.2	1.09238	0.50962	0.29834	27.31	0.00716	50.15	15.779	0.06381	27.456	7.17	50.15
1	15	112.35	44.64	68.697	20.39	26.2	2.78422	0.70887	0.29834	10.72	0.00716	50.15	16.673	0.06039	34.921	7.17	50.15
5	15	138.11	58.95	75.315	24.06	26.2	5.61866	0.88660	0.29834	5.31	0.00716	50.15	17.424	0.05779	41.186	7.17	50.15
10	15	142.29	61.27	76.299	24.61	26.2	6.25627	0.91608	0.29834	4.77	0.00716	50.15	17.545	0.05739	42.201	7.17	50.15
15	15	139.19	59.55	75.572	24.21	26.2	5.77797	0.89421	0.29834	5.16	0.00716	50.15	17.455	0.05769	41.448	7.17	50.15
20	15	134.85	57.14	74.532	23.63	26.2	5.16061	0.86372	0.29834	5.78	0.00716	50.15	17.329	0.05811	40.393	7.17	50.15
26	15	130.46	54.7	73.453	23.03	26.2	4.59399	0.83304	0.29834	6.49	0.00716	50.15	17.201	0.05854	39.325	7.17	50.15
30	15	126.59	52.55	72.479	22.49	26.2	4.13978	0.80617	0.29834	7.21	0.00716	50.15	17.088	0.05893	38.384	7.17	50.15
40	15	122.31	50.17	71.375	21.87	26.2	3.68248	0.77663	0.29834	8.10	0.00716	50.15	16.963	0.05936	37.342	7.17	50.15
50	15	117.10	47.28	69.996	21.11	26.2	3.18614	0.74106	0.29834	9.36	0.00716	50.15	16.812	0.05989	36.077	7.17	50.15
60	3	138.88	59.38	77.189	25.10	26.2	5.73245	0.94349	0.36631	6.39	0.00882	61.74	17.492	0.05766	43.232	8.82	61.74
70	3	162.03	72.24	82.165	27.87	26.2	10.17597	1.11034	0.36631	3.60	0.00882	61.74	18.168	0.05551	48.880	8.82	61.74
80	3	166.19	74.55	82.999	28.33	26.2	11.22451	1.14068	0.36631	3.26	0.00882	61.74	18.290	0.05515	49.894	8.82	61.74
90	3	163.35	72.97	82.430	28.02	26.2	10.49794	1.11992	0.36631	3.49	0.00882	61.74	18.207	0.05540	49.200	8.82	61.74
100	3	159.06	70.59	81.559	27.53	26.2	9.47899	1.08873	0.36631	3.86	0.00882	61.74	18.082	0.05578	48.155	8.82	61.74
125	1.5	166.23	74.57	84.773	29.32	26.2	11.23397	1.20761	0.45078	4.01	0.01089	76.22	18.351	0.05507	52.251	10.89	76.22
150	1.5	170.44	76.91	85.567	29.76	26.2	12.38894	1.23869	0.45078	3.64	0.01089	76.22	18.474	0.05471	53.283	10.89	76.22
200	1.5	166.57	74.76	84.838	29.35	26.2	11.32421	1.21013	0.45078	3.98	0.01089	76.22	18.361	0.05504	52.335	10.89	76.22
250	1.5	160.97	71.65	83.759	28.75	26.2	9.92191	1.16895	0.45078	4.54	0.01089	76.22	18.197	0.05554	50.964	10.89	76.22
300	1.5	156.13	68.96	82.802	28.22	26.2	8.83071	1.13346	0.45078	5.10	0.01089	76.22	18.055	0.05598	49.778	10.89	76.22
400	1	157.28	69.6	84.789	29.33	26.2	9.08060	1.20824	0.53470	5.89	0.01296	90.71	18.148	0.05580	52.400	12.96	90.71
500	1	157.21	69.56	84.775	29.32	26.2	9.06481	1.20771	0.53470	5.90	0.01296	90.71	18.146	0.05581	52.383	12.96	90.71
600	1	154.54	68.08	84.264	29.04	26.2	8.49667	1.18806	0.53470	6.29	0.01296	90.71	18.067	0.05605	51.728	12.96	90.71
700	1	151.09	66.16	83.590	28.66	26.2	7.80502	1.16263	0.53470	6.85	0.01296	90.71	17.966	0.05637	50.878	12.96	90.71
800	1	147.42	64.12	82.863	28.26	26.2	7.12327	1.13567	0.53470	7.51	0.01296	90.71	17.858	0.05671	49.975	12.96	90.71
900	1	143.74	62.08	82.122	27.85	26.2	6.49297	1.10879	0.53470	8.24	0.01296	90.71	17.750	0.05706	49.073	12.96	90.71
1000	1	140.31	60.17	81.416	27.45	26.2	5.94664	1.08370	0.53470	8.99	0.01296	90.71	17.649	0.05738	48.228	12.96	90.71
1500	1	133.61	56.45	80.006	26.67	26.2	4.99462	1.03505	0.53470	10.71	0.01296	90.71	17.452	0.05803	46.581	12.96	90.71
2000	1	124.11	51.17	77.920	25.51	26.2	3.86903	0.96655	0.53470	13.82	0.01296	90.71	17.173	0.05897	44.245	12.96	90.71
3000	1	115.00	46.11	75.819	24.34	26.2	3.00225	0.90160	0.53470	17.81	0.01296	90.71	16.905	0.05991	42.006	12.96	90.71
4000	1	107.38	41.88	73.980	23.32	26.2	2.41154	0.84791	0.53470	22.17	0.01296	90.71	16.681	0.06071	40.134	12.96	90.71
5000	1	102.58	39.21	72.778	22.65	26.2	2.09284	0.81433	0.53470	25.55	0.01296	90.71	16.540	0.06123	38.953	12.96	90.71
6000	1	99.55	37.53	72.004	22.22	26.2	1.91157	0.79333	0.53470	27.97	0.01296	90.71	16.451	0.06156	38.209	12.96	90.71
7000	1	97.48	36.38	71.466	21.93	26.2	1.79547	0.77902	0.53470	29.78	0.01296	90.71	16.390	0.06179	37.701	12.96	90.71
8000	1	95.92	35.51	71.054	21.70	26.2	1.71174	0.76823	0.53470	31.24	0.01296	90.71	16.344	0.06196	37.316	12.96	90.71
9000	1	94.66	34.81	70.721	21.51	26.2	1.64685	0.75957	0.53470	32.47	0.01296	90.71	16.307	0.06211	37.006	12.96	90.71
10000	1	93.58	34.21	70.433	21.35	26.2	1.59294	0.75217	0.53470	33.57	0.01296	90.71	16.275	0.06223	36.740	12.96	90.71

Table XXVII-3. Psychrometric Properties of Ventilation Air in Emplacement Drift - at 600 m with Constant Moisture

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	M
		Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Density	Enthalpy		
Test Sta. & Remarks	Temp.	Temp.	Temp.	Temp.	Pres. Ave.	Pres. at Td	Pres. at Tw	Vapor Pres.	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.	Moisture	Moisture	
	Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H ₂ O)	W*7000	v	w	h	g/kg	W*7000	
	Equiv. of	Observed	Adjusted	Equiv. Of	Observed	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	input	
	Col D	Field	to fit	Col. E	Field											Col M x 0.1429	
Year	Air Quantity			Col. M													
	m ³ /s	°F	°C	°F	°C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hum.	lb/lb dry air	Grains/lb air	ft ³ /lb dry air	lb/ft ³	Btu/lb air	Gram/Kg	Grains/lb air
		Input ^oC			Input "Hg											Input	
		600m														600m	
0.0001	15	81.66	27.59	58.648	14.80	26.2	1.09238	0.49844	0.28128	25.75	0.00675	47.25	15.769	0.06383	27.002	6.75	47.25
1	15	112.35	44.64	68.191	20.11	26.2	2.78422	0.69666	0.28127	10.10	0.00675	47.25	16.662	0.06041	34.461	6.75	47.25
5	15	138.11	58.95	74.879	23.82	26.2	5.61866	0.87380	0.28127	5.01	0.00675	47.25	17.412	0.05781	40.721	6.75	47.25
10	15	142.29	61.27	75.872	24.37	26.2	6.25627	0.90320	0.28127	4.50	0.00675	47.25	17.534	0.05740	41.736	6.75	47.25
15	15	139.19	59.55	75.138	23.97	26.2	5.77797	0.88139	0.28127	4.87	0.00675	47.25	17.444	0.05770	40.983	6.75	47.25
20	15	134.85	57.14	74.088	23.38	26.2	5.16061	0.85098	0.28127	5.45	0.00675	47.25	17.318	0.05812	39.929	6.75	47.25
26	15	130.46	54.7	72.998	22.78	26.2	4.59399	0.82039	0.28127	6.12	0.00675	47.25	17.190	0.05855	38.862	6.75	47.25
30	15	126.59	52.55	72.014	22.23	26.2	4.13978	0.79361	0.28127	6.79	0.00675	47.25	17.077	0.05894	37.921	6.75	47.25
40	15	122.31	50.17	70.898	21.61	26.2	3.68248	0.76417	0.28127	7.64	0.00675	47.25	16.952	0.05937	36.880	6.75	47.25
50	15	117.10	47.28	69.504	20.84	26.2	3.18614	0.72872	0.28127	8.83	0.00675	47.25	16.801	0.05991	35.616	6.75	47.25
60	3	138.88	59.38	75.065	23.92	26.2	5.73245	0.87924	0.28127	4.91	0.00675	47.25	17.435	0.05773	40.909	6.75	47.25
70	3	162.03	72.24	80.276	26.82	26.2	10.17597	1.04422	0.28127	2.76	0.00675	47.25	18.109	0.05558	46.535	6.75	47.25
80	3	166.19	74.55	81.147	27.30	26.2	11.22451	1.07428	0.28127	2.51	0.00675	47.25	18.230	0.05521	47.545	6.75	47.25
90	3	163.35	72.97	80.554	26.97	26.2	10.49794	1.05371	0.28127	2.68	0.00675	47.25	18.147	0.05547	46.854	6.75	47.25
100	3	159.06	70.59	79.643	26.47	26.2	9.47899	1.02282	0.28127	2.97	0.00675	47.25	18.022	0.05585	45.813	6.75	47.25
125	1.5	166.23	74.57	81.155	27.31	26.2	11.23397	1.07454	0.28127	2.50	0.00675	47.25	18.231	0.05521	47.554	6.75	47.25
150	1.5	170.44	76.91	82.019	27.79	26.2	12.38894	1.10510	0.28127	2.27	0.00675	47.25	18.354	0.05484	48.578	6.75	47.25
200	1.5	166.57	74.76	81.226	27.35	26.2	11.32421	1.07701	0.28127	2.48	0.00675	47.25	18.241	0.05518	47.637	6.75	47.25
250	1.5	160.97	71.65	80.051	26.69	26.2	9.92191	1.03656	0.28127	2.83	0.00675	47.25	18.078	0.05568	46.277	6.75	47.25
300	1.5	156.13	68.96	79.007	26.12	26.2	8.83071	1.00174	0.28127	3.19	0.00675	47.25	17.937	0.05612	45.100	6.75	47.25
400	1	157.28	69.6	79.258	26.25	26.2	9.08060	1.01001	0.28128	3.10	0.00675	47.25	17.970	0.05601	45.380	6.75	47.25
500	1	157.21	69.56	79.242	26.25	26.2	9.06481	1.00949	0.28128	3.10	0.00675	47.25	17.968	0.05602	45.363	6.75	47.25
600	1	154.54	68.08	78.660	25.92	26.2	8.49667	0.99039	0.28128	3.31	0.00675	47.25	17.891	0.05626	44.715	6.75	47.25
700	1	151.09	66.16	77.893	25.50	26.2	7.80502	0.96568	0.28128	3.60	0.00675	47.25	17.790	0.05658	43.875	6.75	47.25
800	1	147.42	64.12	77.062	25.03	26.2	7.12327	0.93954	0.28128	3.95	0.00675	47.25	17.683	0.05692	42.983	6.75	47.25
900	1	143.74	62.08	76.214	24.56	26.2	6.49297	0.91351	0.28128	4.33	0.00675	47.25	17.576	0.05727	42.090	6.75	47.25
1000	1	140.31	60.17	75.404	24.11	26.2	5.94664	0.88924	0.28128	4.73	0.00675	47.25	17.476	0.05759	41.255	6.75	47.25
1500	1	133.61	56.45	73.783	23.21	26.2	4.99462	0.84231	0.28128	5.63	0.00675	47.25	17.281	0.05824	39.627	6.75	47.25
2000	1	124.11	51.17	71.370	21.87	26.2	3.86903	0.77651	0.28127	7.27	0.00675	47.25	17.005	0.05919	37.317	6.75	47.25
3000	1	115.00	46.11	68.927	20.51	26.2	3.00225	0.71447	0.28127	9.37	0.00675	47.25	16.740	0.06013	35.104	6.75	47.25
4000	1	107.38	41.88	66.775	19.32	26.2	2.41154	0.66348	0.28127	11.66	0.00675	47.25	16.518	0.06094	33.253	6.75	47.25
5000	1	102.58	39.21	65.362	18.53	26.2	2.09284	0.63175	0.28127	13.44	0.00675	47.25	16.378	0.06146	32.085	6.75	47.25
6000	1	99.55	37.53	64.449	18.03	26.2	1.91157	0.61197	0.28127	14.71	0.00675	47.25	16.290	0.06179	31.350	6.75	47.25
7000	1	97.48	36.38	63.814	17.67	26.2	1.79547	0.59953	0.28127	15.67	0.00675	47.25	16.230	0.06202	30.847	6.75	47.25
8000	1	95.92	35.51	63.328	17.40	26.2	1.71174	0.58841	0.28127	16.43	0.00675	47.25	16.184	0.06219	30.467	6.75	47.25
9000	1	94.66	34.81	62.932	17.18	26.2	1.64685	0.58029	0.28127	17.08	0.00675	47.25	16.147	0.06233	30.160	6.75	47.25
10000	1	93.58	34.21	62.591	17.00	26.2	1.59294	0.57336	0.28127	17.66	0.00675	47.25	16.116	0.06246	29.898	6.75	47.25

Table XXVII-4. Comparison of Enthalpy with Variable or Constant Moisture

Year	Case No.	Air Flow Rate (m ³ /s)	Enthalpy Difference (%)	Enthalpy (BTU/lb)	
				With Variable Moisture	With Constant Moisture
0.0001	1	15	1.68	27.46	27.00
1	2	15	1.34	34.92	34.46
5	3	15	1.14	41.19	40.72
10	4	15	1.12	42.20	41.74
15	5	15	1.13	41.45	40.98
20	6	15	1.16	40.39	39.93
26	7	15	1.19	39.33	38.86
30	8	15	1.22	38.38	37.92
40	9	15	1.25	37.34	36.88
50	10	15	1.29	36.08	35.62
60	11	3	5.68	43.23	40.91
70	12	3	5.04	48.88	46.53
80	13	3	4.94	49.89	47.55
90	14	3	5.01	49.20	46.85
100	15	3	5.11	48.15	45.81
125	16	1.5	9.88	52.25	47.55
150	17	1.5	9.69	53.28	48.58
200	18	1.5	9.86	52.34	47.64
250	19	1.5	10.13	50.96	46.28
300	20	1.5	10.37	49.78	45.10
400	21	1	15.47	52.40	45.38
500	22	1	15.48	52.38	45.36
600	23	1	15.68	51.73	44.72
700	24	1	15.96	50.88	43.88
800	25	1	16.27	49.98	42.98
900	26	1	16.59	49.07	42.09
1000	27	1	16.90	48.23	41.25
1500	28	1	17.55	46.58	39.63
2000	29	1	18.56	44.25	37.32
3000	30	1	19.66	42.01	35.10
4000	31	1	20.69	40.13	33.25
5000	32	1	21.40	38.95	32.09
6000	33	1	21.88	38.21	31.35
7000	34	1	22.22	37.70	30.85
8000	35	1	22.48	37.32	30.47
9000	36	1	22.70	37.01	30.16
10000	37	1	22.89	36.74	29.90

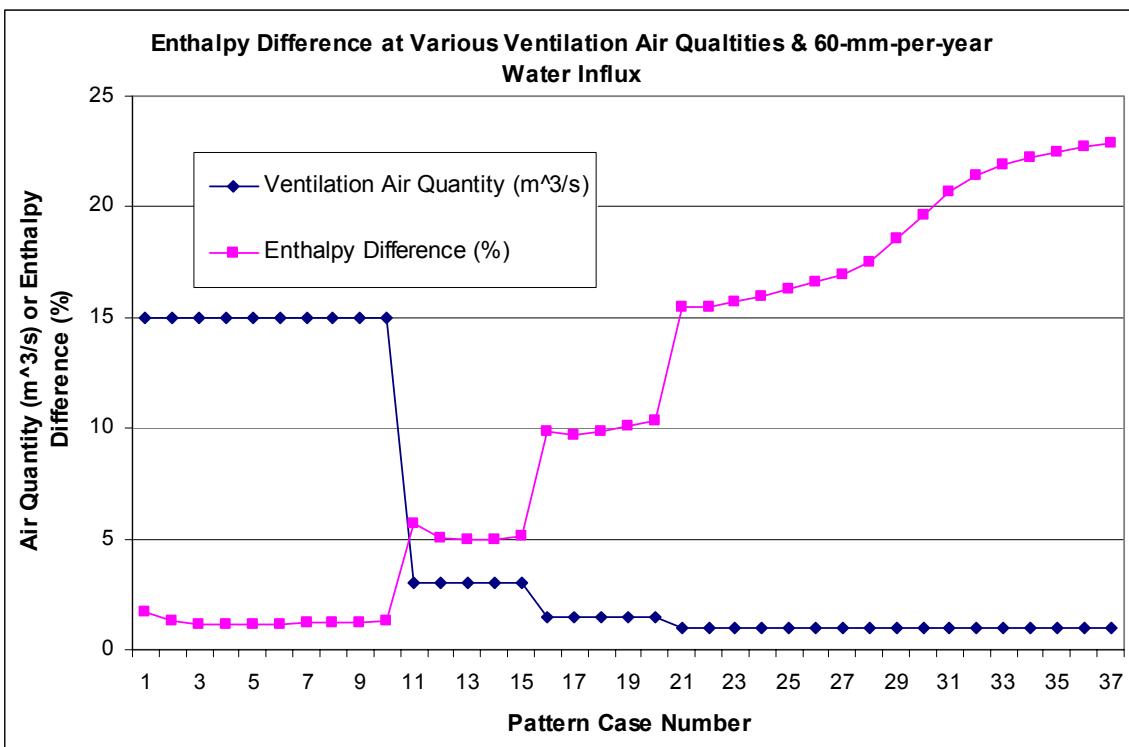


Figure XXVII-1. Enthalpy Difference at Various Ventilation Air Quantities and 60-mm per Year Water Influx